Annual Report of the

Board of Scientific Advice for India

for the year 1909-10

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Board of Scientific Advice for India

for the year 1909-10

Calcutta
Superintendent Government Printing, India
1911

Price Re. 1 or 1s. 6d.

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Sub-Committee A.—(*Meteorology, Terrestrial Magnetism and Cognate Subjects*).

1. The Surveyor-General of India (Chairman);
2. The Director-General of Observatories;
3. The Director, Geological Survey of India.

Sub-Committee B.—(*Agricultural Products*).

1. The Director, Botanical Survey of India (Chairman);
2. The Superintendent, Industrial Section, Indian Museum;
3. The Inspector-General of Agriculture.

Sub-Committee C.—(*Soils and Manures*).

1. The Inspector-General of Agriculture (Chairman);
2. The Director, Geological Survey of India;
3. The Inspector-General of Forests.

Sub-Committee D.—(*Forest Products*).

1. The Inspector-General of Forests (Chairman);
2. The Superintendent, Industrial Section, Indian Museum;
3. The Director, Botanical Survey of India.

Sub-Committee E.—(*Veterinary Subjects*).

1. The Inspector-General, Civil Veterinary Department (Chairman);
2. The Inspector-General of Agriculture;
3. The Superintendent of the Indian Museum.

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2. The Director-General of Observatories;
3. The Superintendent, Industrial Section, Indian Museum;
4. Colonel S. G. Burrard, R.E., F.R.S.;
5. The Director, Geological Survey of India.

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ANNUAL REPORT

OF THE

BOARD OF SCIENTIFIC ADVICE FOR INDIA

1909-1910.

SUMMARY OF PROCEEDINGS.

Eighteenth Meeting held at Simla on the 9th May 1910.

Correspondence forwarded under Government Endorsement between Government and the Inspector-General of Agriculture in which were embodied memoranda on the work in progress in plant breeding—particularly of wheat and tobacco—on Mendelian lines in the section of Economic Botany and on the investigation of soil gases and availability of plant food being conducted in the Chemical section of the Agricultural Research Institute at Pusa was read and recorded.

Correspondence forwarded under Government Endorsement in which were set forth the views of the Observatories Committee of the Royal Society of London on Meteorological work in India was read and recorded. The Observatories Committee expressed their satisfaction with the various lines of investigation conducted by the Meteorological Department.

The programmes for 1910-1911 of the various Departments were discussed and with minor emendations in several were accepted.

Nineteenth Meeting held at Calcutta on the 20th December 1910.

After considering correspondence forwarded under Government Endorsement between the India Office and the Director of the Imperial Institute, London, on the subject of furnishing the Indian Departments interested with the names of experts consulted by the Director of the Imperial Institute in scientific and commercial enquiries made on behalf of the Government of India the Board resolved to amplify their original resolution of the fifteenth meeting by explaining that they would be obliged if, in addition to the names of external referees consulted by the Director of the Imperial Institute, the names of officers of the Imperial Institute also would be furnished when asked for.

Correspondence under Endorsement from Government on the remarks of the Advisory Committee of the Royal Society of London regarding the work of the Geological Survey and Civil Veterinary Departments and embodying the revised arrangements concluded with the Royal Society in respect of the future functions of their Advisory Committee was read and recorded.

The Board then considered the draft Annual Report for 1909-1910. It was resolved that contributors to the Report should restrict their accounts to scientific work coming under the various headings of the Report, and should not deal with matters of departmental administration or detail. The advisability of combining the present separate accounts on chemical work into one section; of combining Botanical Survey with Forest Botany and Agricultural Entomology with Forest Entomology was discussed and the Secretary to the Board was authorised to communicate with the Departments concerned with a view to linking up those sections of the Report in future.

The question of whether a section of the Annual Report should in future be devoted to the subject of scientific Libraries in India was referred to Sub-Committee F (Libraries) for consideration and report to the Board at the next meeting.

INDUSTRIAL AND AGRICULTURAL CHEMISTRY.

BY

D. HOOPER, F.I.C., F.C.S.,

AND

J. W. LEATHER, PH.D., F.I.C.

This report is a review of the chemical work done during the year in connection with Indian industries and agriculture, and on Indian material examined in other countries. It indicates a vast amount of scientific activity of which the results are a useful contribution to our knowledge of indigenous products and their technical applications. For the purposes of the report the classification of last year has again been followed :—

i. Analytical methods.
ii. Industries based on mineral production.
iii. Chemistry and physics of soils and water manuring.
iv. Analyses of organic raw products and manufacturing processes connected with them.

1. Gums, resins and rubber.
2. Fixed and volatile oils.
3. Dyes and dyeing.
4. Tans and tanning.
5. Fibres and paper.
6. Flour, sugars, starch, foods.
7. Accessories to human food.
8. Spirits.
9. Drugs.

(i) Analytical Methods.

Temperature of reference for India.

The Committee appointed by the Asiatic Society of Bengal to collect evidence and opinions on the adoption of a temperature of reference suitable for India has published its report. The temperature of 30° C. has been recommended; 40 scientific workers in India out of 50 being in favour of this temperature for chemical and physical operations. India being only one of the countries of the tropics the matter has been considered of sufficient importance to

be referred to the Royal Society for submission to the International Association of Academies; for it is only in some such manner that other countries would have an opportunity of expressing their opinions.

The Chief Chemical Examiner, Ordnance Department, has supplied the following information with regard to experiments on explosives made in his laboratory.

Storage of explosives.

Much trouble has been experienced in storing explosives in India, as they are liable to decompose and eventually ignite in consequence of the high temperature of storage. Modern explosives are composed mostly of endothermic compounds, that is to say they can only be built up from their elements with absorption of heat. Such substances are necessarily unstable to a greater or less extent, and the rate of decomposition increases rapidly with the temperature. In the case of the two most important explosive compounds, gun-cotton and nitro-glycerine, the rate of decomposition is rapid enough even at a temperature of 140° F. to be quite easy to detect in the laboratory, and the rate is about doubled for every increase of 9° F. in the temperature. Moreover, the reaction is subject to autocatalysis, for the nitrous oxide and perhaps other products of decomposition, which accumulate in the course of time greatly increase the rate of decomposition. If these explosives therefore are stored for long periods at the temperatures prevailing in most parts of India, they are liable to decompose more and more rapidly, until finally the rate of decomposition becomes so great that it raises the temperature to the point of ignition and the explosive catches fire.

Hence the importance of keeping the magazines cool especially if the explosives are to be kept for some years before use. Various structural alterations are to be tried in the magazines of the Ordnance Department and the Fort Armaments with a view to reducing the temperature. In the larger magazines refrigerating machinery will probably be introduced to artificially reduce the temperature.

Records of the temperatures of all magazines are kept and the results tabulated. In order to have a ready means of comparing the records for different magazines or the same magazine in different years, a method has been worked out of plotting the figures for each month round the circumference of a circle and determining the position of the "specific gravity."

Carbon dioxide apparatus.

Manindra Nath Banerjee has described a convenient apparatus for the determination of equivalents of metals and the estimation of carbon dioxide both directly and indirectly. The equivalents of the following metals have been found by the apparatus: magnesium, zinc, aluminium and sodium.

Nitrites.

P. C. Ray in collaboration with students has continued his studies of the nitrites of mercury and other metals, in regard to which several papers have appeared during the year. On heating di-mercurammonium nitrite, it commences to decompose at about 140° and the change is complete at 250° C.; the chief products are mercury, mercuric oxide, mercuric nitrate, nitrogen and nitrous oxide.

Several double nitrites, namely, mercuric calcium nitrite, mercuric strontium nitrite and mercuric barium nitrite have been prepared by mixing the respective nitrites with mercurous nitrite, separating the precipitated mercury and evaporating in a vacuum.

(ii) Industries based on Mineral Production.

Indian Magnesite.

Mr. H. H. Davis in 1909 read a paper on The Indian Magnesite Industry. According to the writer, Dr. Macleod was the first person to suggest the possibility of starting a magnesite industry at Salem, Madras, in 1826. But work on a somewhat large scale has been begun only lately. From the analyses of samples of Indian magnesite by the author, as well as by other chemists, it was found that the mineral was of a very good quality, the percentages of lime, silica, iron oxide and alumina being exceptionally small.

The calcined magnesite which is of great commercial importance is prepared from the Indian mineral. The lightly calcined or caustic magnesia is largely used as an ingredient for cement. The dead-burnt or shrunk magnesia is used as a refractory lining for furnaces, converters in the steel industry and for making refractory bricks.

The Indian magnesite industry is at present in its infancy, but with the erection of suitable plant it is expected to become a very profitable one.

Loss of sulphur in vitriol works.

Mr. Biraj Mohan Das has carefully calculated the amount of loss of sulphur in the manufacture of vitriol. All his experiments and observations have been made on the vitriol chambers of the Bengal Chemical and Pharmaceutical Works, Limited. The total loss has been sub-divided under the following heads :—

(1) As sulphur dioxide in the exit gas	1·5 per cent.
(2) As sulphur trioxide	1·0 „
(3) As sulphur by sublimation, and as sulphur oxides by premature condensation, etc. . . .	1·5 „

Total loss calculated as sulphur dioxide is 4 per cent. on the sulphur dioxide entering the chamber, whereas the best managed European works lose totally 1·5 per cent. to 2·5 per cent. on sulphur dioxide introduced.

Saltpetre.

In connection with saltpetre Babu Manindra Nath Banerjee has published a series of articles in the *Modern Review* on "The Nitre Industry in Tirhut." Analyses are given of the products and suggestions are made for the improvement of the manufacture.

(iii) Chemistry and Physics of soils and water.

Water requirements of crops.

The investigation of the amounts of water required by crops in India, which has been in progress for some years, (see Memoir of the Department of Agriculture, No. 8, Chemical Series, and this report for 1908-09, p. 12) has been continued both in the field and by pot-culture methods, the results of which are about to be published. The newer pot-culture tests were made in part in order to check previous work and in part to ascertain what effect, if any, the nature of the soil has on the transpiration ratio. Regarding the former section of the work, the check consisted in the employment of larger jars of soil and these substantiated previous tests in shewing that the larger the mass of soil employed, the lower is the transpiration ratio. The employment of different soils showed that, given a liberal water supply this factor has no influence on the transpiration ratio.

The field tests have been conducted for three cold weather seasons at Cawnpore and at Pusa and have resulted in shewing that (i) the crop occasions a marked decrease of water concentration in the soil within the root range of some 7 to 9 feet, but that below this depth the water-concentration remains practically constant; (ii) that practically all the water assimilated by the plant or lost into the atmosphere by evaporation from the land surface is accounted for by this decrease of concentration; (iii) that a comparison of these data with the weight of crop gives a ratio closely approximating to that obtained by pot-culture methods and hence support them.

This work has also shown how very great a value would be possessed by an accurate method for the determination of the quantity of water which can move through soils under the influence of surface tension.

Drainage.

The records which have been maintained for some years at Cawnpore and Pusa on the amounts of water draining away from arable and from cropped land, and the amounts of plant food, more especially nitrogen-compounds which are at the same time removed, have been continued, and in respect of nitrates somewhat extended. It is proposed to publish these data shortly. In addition to providing a comparison with the Rothamsted data, they show the effect of crops both on the amount of drainage and its constituents; certain deductions are also possible in relation to the nature of drainage.

Soil gases.

Mr. W. H. Harrison has carried out a series of analyses of the gases which are evolved from paddy fields which have been green-manured. The work has not

been published, but Mr. Harrison has courteously intimated the following as a typical sample :—

CO_2	5·6 per cent.
O	·4 „
CH_4	20·2 „
N	73·8 „

Usar soils.

The examination of alkali lands in the United Provinces, to which reference was made in last year's report, is being continued. A new test has been devised for estimating the rate at which water can percolate through soils. By its aid the great difference between the physical state of some alkali lands and ordinary arable soil has been demonstrated, the former being only one-tenth down to one-hundredth part as permeable as the latter.

(iv) Analyses of Raw Products and Industries connected with them.

1. Gums, Resins and Rubber.—Five samples of rubber prepared from trees grown in the Government Experimental Gardens at Kullar and Burliar in the Nilgiri Hills have been analysed at the Imperial Institute. The percentage of caoutchouc is given as follows :—

	Caoutchouc.
No. 1 Ceara rubber (*Manihot Glaziovii*)	80·2 per cent.
„ 2 Castilloa rubber (*Castilloa elastica*)	62·7 „
„ 3 Do.	86·1 „
„ 4 Para rubber (*Hevea brasiliensis*)	92·0 „
„ 5 Do.	91·5 „

The values per lb. in London are given as : No. 1, *5s. 6d.* ; No. 2, *3s. 2d.*—*3s. 4d.* ; No. 3, *3s. 6d.*—*3s. 8d.* ; No. 4, *5s.*—*5s. 2d.* ; No. 5, *5s. 4d.*—*5s. 5d.*

Cotton seed oil.

2. Fixed Oils.—The Director-General of Commercial Intelligence has interested himself with regard to the utilisation of cotton seed oil and has supplied samples of the crude and refined oil to the Industrial Section of the Indian Museum for examination. The chief problems for solution were : (1) the proportion of stearin or solid fats present in the oil expressed from Indian grown seed ; (2) the nature and amounts of the acrid and colouring principle ; and (3) the practicability of using the oil for edible purposes. Samples of the oil obtained from American seed grown at Dharwar and expressed at Cawnpore were obtained for experiment. At the winter temperature of Calcutta (22°—24°C.) very little stearin is deposited by this oil, but by chemical methods 29·5 and 32·4 per cent. of solid white fats were separated

from two different samples. Previous investigators have found from 22·3 to 32·6 per cent. of solid fats in commercial cotton seed oil. Dr. Lewkowitsch quotes some recent analyses in which the proportions of solid fatty acids in American and Egyptian cotton seed varied from 20·9 to 24·4 per cent. From these results we may conclude that just as much, if not more, stearin could be obtained from Indian oil. The separation of the solid fat would of course not be so easy a matter in India as it is in temperate climates.

As regards the acridity of crude cotton seed oil it is evident that this is intimately associated with the reddish-brown colouring matter or bloom. No figures are available for showing the amount present in other oils, but the acid value of two kinds of oil from American seed from Dharwar gave respectively 7·5 and 9·7 per cent. By using an amount of alkali corresponding to these figures and subsequent washing, the colouring matter, bloom and acridity are entirely removed, and a refined oil obtained having the same yellow colour and other properties of the Egyptian refined oil. The objectionable features of Indian cotton seed oil are removed by this method with very little loss on the bulk of the oil. Most of the edible cotton seed oil made in Britain is prepared from Egyptian seed. Indian cotton seed oil is said to have a disagreeable flavour either due to the excess of fibre in the seed or the condition of the seed when it arrives at the factory; the refining of the Indian oil is also said to be more costly than Egyptian. From the above experiments it would appear that with very careful screening of the seed before crushing and by washing the oil thoroughly in the process of refining, a perfectly edible oil could be produced for local use.

Soy beans.

The interest that has lately been taken in Soy beans and its oil has prompted the Reporter on Economic Products to examine the beans grown in India. The Directors of Agriculture have supplied samples from the chief districts where they are grown. Ninety-one samples have been received from Burma, Naga Hills, Shillong, Kalimpong, Kangra, Simla, Kashmir, Patna, Nagpur, Poona and 37 villages of the United Provinces. The oil content ranged from 13·5 to 22·4 per cent., the Poona samples yielding the highest amount. As far as the yield of oil is concerned, Soy beans cultivated in India afford almost as much as is found in those from Manchuria and Japan. Only certain localities in India are suitable for growing *Glycine*, and these are upland situations in Burma, Assam and the lower valleys of the Himalaya.

Lesser known oils.

The testing of the lesser known fixed oils has been continued by Mr. Hooper with some interesting results. The first to be considered is that of *Celastrus paniculata*. Malkanguni seeds yield a reddish oil, depositing white fats on standing. The oil is reported to have peculiar medicinal properties and is given as a brain stimulant to students and pundits. The seeds are small, red and angular—a sample from Madras afforded 43·25 and one from the Punjab 44·7 per cent. of a thick reddish bitter oil. Seven samples of oil received from Burma, Garhwal, Barhaich, Dehra Dun and Gorakhpur, had the following constants: specific gravity at 50°C. ·942 to ·956; acid value, 34·7 to 101·0; saponification value, 218·0 to 246·7; iodine value, 75·5 to 100·8; Reichert-Meissl value, 41 to 42. The high saponification and Reichert-Meissl values agree with published analyses of the oil of the staff tree (*Celastrus senegalensis*) and spindle tree (*Euonymus europeus*) of the same natural order.

Pyinkado seed (*Xylia dolabriformis*).—The hard seeds of this tree, frequent in Burma, yield to ether 21·1 per cent. of a yellow non-drying oil melting at 22°. The constants were: acid value, 22·0; saponification value, 176·3; iodine value, 89·4. 31·6 per cent. of the mixed lead salts was insoluble in ether and the liberated fat acid melted at 69°, consisting probably of stearic acid.

Mimusops hexandra.—The tree is a native of the Deccan and is cultivated in Northern India. Kirni seeds yield a clear yellowish non-drying oil depositing a white fat at 30°. The specific gravity at 40° is 0·905 and acid value 25·5. The constants are: saponification value, 195·4; iodine value, 72·5; Reichert-Meissl value, 0·17.

Origanum vulgare.—The minute seeds of this labiate plant have been reported as oleaginous. A sample from Ramnagar, United Provinces, yielded to ether 27·3 per cent. of a drying oil. The oil had an acid value of 11·3, saponification value 194·9, and iodine value 190·5. The iodine value is, therefore, higher than that of linseed oil, and in this respect resembles the fatty oil of *Perilla ocimoides*, a labiate plant indigenous in India, China and Japan.

Prunus Puddum.—The seeds of the Bird Cherry growing in the Himalayas yield another peculiar oil remarkable for its siccative properties. The oil extracted by ether commenced to form a skin and absorb oxygen as soon as evaporation was complete. Under the circumstances it was difficult to estimate its iodine value. A small sample was crushed in a mill, and the oil treated at once by Hubl's solution showed a value of 172.

It dried to a skin in glass in two hours; boiled linseed oil required 4 hours. The pressed cake and seeds distilled with water afforded considerable quantities of hydrocyanic acid and benzoyl aldehyde (oil of bitter almonds).

Volatile Oils.—Experiments have been made with lemon grass from Jalpaiguri, Bengal, to see what effect the season has upon the yield and character of the oil. In July 1909 Mr. Burkill distilled grass before the flowering period, both locally and at Calcutta. Two months later in September he again distilled the grass before flowering. Finally the grass was cut while in flower and distilled, first the flowers were used and then for another experiment the leaves only. The samples were examined by Messrs. Schimmel & Co., but no differences of any importance were discoverable in the oil from the flowers and the leaves; the samples showed no material divergence from those prepared from herb before flowering and no such differences were observable among the various oils distilled before flowering. The oil from the leaves is a little richer in aldehydes and rather heavier than the oil from the flowers, but the few investigations do not admit of any final conclusions.

Lemon grass oil.

Experiments made by A. J. Ultie in Java have shown that manuring does not affect the oil content of lemon grass.

Palmarosa oil (*Cymbopogon Martini*).—Mr. Burkill has supplied further details respecting the distillation of this oil as practised in British India, and Messrs. Schimmel & Co., Leipzig, have reproduced in their report for April 1910 some excellent photographs of the process as conducted in the district of Khandesh. Samples of the oil collected by Mr. Burkill on the occasion of his visit have been chemically examined by Messrs. Schimmel & Co., and the results show the difference between the Motia and Sofia oils which occur in this district. The Motia (Palmarosa) oil has an average specific gravity of 0·891 and a geraniol content of 91·3, while the Sofia (ginger grass) oil has an average specific gravity of 0·941 and a geraniol content of 42·7. The Motia oil dissolves in 1·5 volumes of 70 per cent. alcohol and the Sofia oil requires 2 per cent. for solution. The Palmarosa grass is distilled in the low-lying situations and the ginger grass on the plateau of Akrani. Great credit is due to Mr. Burkill for having solved the mystery that has long surrounded the origin of these two commercial oils.

Palmarosa oil.

The essential oil of *Blumea balsamifera* has been investigated by R. Jonas. The brown oil from which a portion of the camphor (laevo-borneol) had been pre-

Blumea balsamifera.

viously removed had the following characters: specific gravity 0·950 at 15° C., acid value, 23·35; ester value, 1; acetyl value, 19·8. It contained cineol, limonene, borneol, laevo-camphor, sesquiterpenes and sesquiterpene alcohols, and a phenol identified as phloracetophenonedimethyl ether, in colourless crystals melting at 32—33°C. It gives a deep red colour with ferric chloride. The oil from different sources varies considerably in composition. Messrs. Schimmel found in a sample of the oil received from Mr. R. S. Pearson, Dehra Dun, about 75 per cent. of l-camphor and only 25 per cent. of oil. The crude product showed a specific rotation of 46·26, its melting point being 175°. The borneol content of the Ngai camphor was calculated at 24·4 per cent.

Cinnamomum Tamala.

Oil of *Cinnamomum Tamala.*—The leaves contain an essential oil, a sample of which was distilled in the Industrial Section of the Museum and examined by Messrs. Schimmel & Co. with the following result. The oil was of a lemon yellow colour and had a clove-like, at the same time slightly peppery, odour. It possessed a phenol content of 78 per cent. consisting of eugenol. In respect to its high eugenol content it is closely allied to the ordinary oil from Ceylon Cinnamon leaves.

Ægle Marmelos.

Ægle Marmelos oil.—The leaves of the Bel or Bael tree yield about 6 per cent. of a faintly yellow coloured essence having the following constants: specific gravity at 25° 0·856, saponification number 10·6. The oil contained d-limonene and no aldehydes. The oil exposed to the air becomes cloudy and left to stand a considerable time, it again becomes clear, but assumes a viscous resinous condition. A resinous product was also obtained from the dried leaves by distillation (Ritsema, quoted in Schimmel's Report, April, 1910).

Dyes.

3. Dyes and Dyeing.—A. G. Perkin has continued his researches on the colouring matter of flowers and has lately investigated the flowers of *Gossypium herbaceum*, in which he finds three hitherto unknown glucosides. Quercimeritrin $C_{21}H_{20}O_{12}$, the main constituent, crystallises with 3 H_2O in small yellow plates m.p. 247—249°, dyes mordanted fabrics very similarly to quercetin and gives with lead acetate an orange-red precipitate. Isoquercitrin, $C_{21}H_{20}O_{12}$, consists of pale yellow needles m.p. 217—219° and is readily hydrolysed by acid with formation of quercetin and dextrose. With lead acetate it gives a bright yellow precipitate. The third glucoside, gossypitrin $C_{21}H_{20}C_{13}$ pale orange yellow needles, m. p. about 200—202°, when hydrolysed gives gossypetin and dextrose. It yields a

bright red precipitate with lead acetate and dyes mordanted fabrics. The flowers yielded 1·86 per cent. of colouring matter, consisting of quercetin mixed with about 10 per cent. of gossypetin.

Andropogon dye.

In a paper on "A Natural Substantive Dyestuff" A. G. Perkin describes his having obtained evidence of the presence of santalin, the colouring matter of sandal wood, in the leaf-sheaths and stems of the great millet (*Andropogon Sorghum*). The principle is termed dura-santalin.

Azo dyes.

The relation between the chemical constitution of the mono-azo dyes and their fastness to light, has been the subject of investigation by Professor E. R. Watson in collaboration with his students. A preliminary classification of known dyes in respect of their constitution and fastness, indicated that the fading in light of these dyes is a property closely associated with the readiness with which that part of the molecule containing (CH) or (NH_2) groups suffers oxidation and that it should hence be possible to predict the fastness of dyes. On applying the theory to dyes which have not been tested for fastness to light, it was found that the theory does not hold at all universally, though certain compounds supported it.

Indigo.

Messrs. Bergtheil and Parnell are engaged in indigo research at Sirseah and a report for the year has been published. The work is being prosecuted on a new basis and valuable results may be expected.

Investigations in England on indigo have been concentrated on indirubin, a natural constituent of the commercial dye. Messrs. W. P. Bloxam and A. G. Perkin have studied its constitution and have devised methods for its estimation.

4. Tans and tanning.—

Pistacia galls.

The leaf gall of *Pistacia mutica* Fisch. et Mey. var. *cabulica* received from Baluchistan, were examined in the Indian Museum. Both the leaves and the galls are used for dyeing and tanning. A separate chemical examination was made of the leaf blades and the galls to see how the substance of the leaf had been changed by the aphid.

The leaves contained 12·85 per cent. of tannin and the galls 15·16. The leaves also contained more albuminoids and ash than the galls. It was shown that the insect had caused a deposition in the galls of resinous and tanning matter and carbohydrates at the expense of the albuminoids. The increase of tannin is not so great as would be expected from the composition of the galls of other species of *Pistacia*.

Canalgre root.

A specimen of the root of the American *Rumex hymenosepalus*, grown in Dharwar, Bombay Presidency, afforded 20·4 per cent. of tannin. This is a better result than was shown last year when the root contained 14·9 per cent. In North America this root at different seasons of the year yields from 16·7 to 28·2 per cent.

The bark of *Cleistanthus collinus*, a tan and fish poison of Madras, has been examined by J. Dekker who has separated saponin, tannin and a crystalline phytosterin.

5. Fibres.—Several samples of fibrous substances have been sent to the Indian Museum, Industrial Section, to ascertain their value for paper-making.

1. Coir refuse (*Cocos nucifera*) from Malabar.
2. Leaves of *Areca Catechu* from the Dooars.
3. Bark of a tree (*Bauhinia*) from the Central Provinces.
4. Stems of grass ("Elkora") from Assam.
5. Sacchi bark (*Aquilaria Agallocha*) from Assam.
6. Do. cleaned and peeled.
7. Do. polished.
8. Rags, raw material.
9. Do. bleached and washed, 2nd stage.
10. Do. do. do. 3rd do.
11. Do. do. do. 4th do.

Analyses of the above gave the following compositions :—

	Cellulose.	Water.	Ash.
1	27·9	10·7	32·9
2	31·9	...	...
3	48·4	10·5	6·6
4	50·4	7·8	3·5
5	41·8	9·3	10·7
6	53·1	10·2	5·2
7	55·1	9·8	6·1
8	57·2	6·4	11·0
9	65·2	8·0	15·0
10	72·8	5·9	8·5
11	78·7	6·4	2·3

The coir refuse is useless on account of the dark coloured coarse fibre and large amount of ash. The bark fibre and grass stems have a satisfactory cellulose content and little ash. The Sacchi bark is a natural paper of Assam, and it is interesting to compare the composition of the crude bark with that prepared for writing. The analyses of rags and the paper pulp made from them in four stages are instructive in showing the rise in the cellulose content in the prepared pulp. In addition to these materials 12 kinds of grasses were sent from Kathiawar for the determination of cellulose. This constituent varied from 31·8 to 43·9 per cent., while the ash content ranged from 4·4 to 14·5 per cent.

Samples of fibres from different parts of India have also been examined at the Imperial Institute and their values at the London market ascertained. The percentages of cellulose in most of them as well as their values are given below :—

	Cellulose.	Value.
Agave rigida from Madras . . .	73·0%	£36—£38 per ton.
Agave americana from Madras .	77·0%	£27—£28 „ „
Furcroea sp. from Madras . .	72·0%	£26—£27 „ „
Manilla hemp from Kullar, Madras . .	70·5%	£23—£24 „ „
Agave fibre from Assam . . .	...	£30 „ „
Agave sisalana from the Andaman Islands	76·6%	£24 „ „
Urena fibre	...	£12-10*s.* to £13 per ton.
Kapok (the seed-floss of *Eriodendron anfractuosum*) from Madras . . .	...	4½*d.* per lb.

6. Flours, sugars, starches, food.—One of the most important questions that has transpired in the East is the alleged connection between rice and the disease beri-beri. Drs. Fraser and Stanton of the Medical Institute for Medical Research of the Federated Malay States propounded the theory in 1909, and Dr. Hignet, the Chief Medical Officer of Siam, supported the conclusions arrived at. A series of experiments was carried out at the Institute on fowls, the result of which was that a large proportion of those fed on overmilled rice alone developed polyneuritis, while all those fed on partially husked paddy or undermilled rice containing a certain amount of the polishings that are removed in the cleaning process, remained healthy. Practical measures were taken in various outbreaks of beri-beri by both Dr. Fraser and Dr. Hignet on the lines suggested by these researches and previously by Dr. Braddon with the best results, and they quoted a large number of cases in which the disease disappeared almost immediately on the substitution of a less completely polished for a white rice diet.

Rice and beri-beri.

The Government of India have deputed Captain E. D. W. Greig, I.M.S., to investigate the subject of beri-beri in Bengal, and Mr. Hooper has been requested to assist in the matter of analysing samples of rice and grains consumed by beri-beri patients. The enquiry has shown a marked difference in the amount of phosphoric pentoxide between the polished and unpolished rice which points to a deficiency of nutrient quantities in the diet which predisposes the system to disease. Rice being one of the principal dietetics in parts of India, further analyses are being made and the albuminoids of the polished and unpolished grains are being studied in the light of the investigations of Rosenheim and Kajiura.

Wheat.

G. Evans has written a note on the annual variations in character of wheats of the Central Provinces (Dept., Agriculture, C. P., Bulletin No. 3, 1910) in which he shows that hard wheats contain more nitrogen than soft grains which seems to indicate that the commercial method of valuation on a basis of hard grain percentage is a very sound one. The facts have long been recognised in Europe. Further investigations on Indian wheats are being carried on and the results will be duly published by the Department of Agriculture.

Sugar-cane.

At the Sabour Agricultural station, Messrs. Taylor and Woodhouse are investigating the period of maturity of the indigenous canes of Bengal.

In connection with analytical tests of a sugar-cane crop, an opportunity was taken at Pusa last season, of estimating the error involved in taking samples of cane, the probable error being calculated by means of the usual formulæ. The test was too limited to admit of publication of the results and the work will be repeated, but it is obvious that a knowledge of how to take the smallest sample which will represent the average composition of a plot or field of cane would be most useful to those engaged on sugar-cane work.

Mahua flowers.

Bassia latifolia (Mahua) flowers were examined by A. H. Church in 1886 (*Nature*, XXXIII, 343-344). They have again been analysed by R. R. Bennett and J. D. W. Anklesaria who obtained 49·8 per cent. of invert sugar and 13·4 per cent. of cane sugar. The flowers also contained 18 per cent. of water, 2·6 per cent. of ash, and 0·7 per cent. of protein. Flowers from trees in the hilly districts contain more sugar than those grown in the plains. An infusion of the flowers fermented with

yeast yield on distillation a spirit with a strong odour; this may be removed by digesting the strong distillate with a potash and redistilling.

Phromnia marginella.

D. Hooper has examined the peculiar saccharine secretion deposited by *Phromnia marginella*, Olivier, on various species of Celastraceæ. The substance is found to be composed principally of dulcitcol or dulcite, an isomeride of mannitol or mannite found in commercial manna.

Butter-fat of Indian buffalo.

Messrs. E. R. Watson, Monohar Gupta and S. C. Ganguli have written an interesting note on the chemical examination of the butter-fat of the Indian buffalo. In a preliminary note on the subject by Watson (*Journ. Asiat. Soc. Bengal*, Vol. II, pp. 293-297) analytical figures were recorded which seemed to show that in Indian buffalo butter-fat the volatile fatty acids were almost entirely butyric. Further investigation recorded in the present paper has not confirmed this result, but has shown that the relative proportion of butyric to caproic acids is practically the same in the Indian buffalo butter-fat and in that of the ordinary cow. The processes of Henriques, Duclaux, Thorp, and Krishner were applied, and it is shown by several tests, illustrated in the paper by means of curves, that the ratio of butyric to caproic acid is practically 2 : 1, the same as in Danish butter-fat. The second section of the work showed that the proportion of volatile acids in Indian buffalo-fat is practically the same as in that of European cows.

Ghee.

A paper on "Analyses of ghee" by E. R. Bolton and C. Revis affords some useful constants of genuine ghee compared with those of samples adulterated with various vegetable fats.

7. Accessories to human food.—The year's contributions to the scientific work on tea include a bulletin by Dr. G. D. Hope intimating further investigations on behalf of the Indian Tea Association. The bulletin deals with experiments on the quality of tea.

Tea.

The effect of *climatic conditions* has been examined more particularly in respect of temperature and rainfall. A higher temperature is accompanied by a higher proportion of total soluble matter in the leaf; good rain produces a like effect, but excessive rain causes a reduction in this respect. The latter effect has been traced to absence of sunlight. Tea grown under artificial shade, as also under trees, contained less soluble matter than tea freely exposed. The same factor likewise occasions a reduction of tannin,

The recommendation is therefore made that where "green manures" are grown they should be restricted to moderate proportions. The *effect of manures* at the Heeleaka Experiment Station has been examined in respect of the total soluble matter in the leaf; artificial nitrogenous fertilizers tend to reduce somewhat the proportion of the total soluble matter at first, though this feature is of no serious moment if the fertilizers are employed in repeated small doses; a "complete" artificial manure has, however, advantages in this respect. Oil cakes do not act prejudicially on the total soluble matter.

In respect of the *manufacture of tea* the investigations had to do with the loss of essential oils during "firing," and it was ascertained that quick firing at a high temperature was accompanied by a smaller loss of these constituents than slow firing at a low one.

Alberkann has investigated a new substance named Assamin in Assam tea seed. These seeds are already known to contain a saponin.

8. Spirits.—During the year the question of the contamination of country liquors with copper salts has been reported on by the Director of the Central Excise Laboratory. In the case of Mahua spirit the cause of this contamination proved to be a copper "soap" produced by the action of organic acids on the still-worm; methods for preventing this action and for cleaning the still-worms by steaming have been proposed and found satisfactory. The limit amount for copper salts in liquors has been fixed at one quarter-grain per gallon, and a suitable test provided for the use of Excise officers which will detect amounts in excess of this limit.

The new *denaturants* for spirit which have been devised by Colonel Bedford have been now adopted throughout India.

A special investigation of toddy with regard to alcoholic strength at various stages and of other points of excise interest was conducted in Bengal and Eastern Bengal.

A report has been made to Government on the *increase of alcoholic strength* in casked spirits, which has been observed in certain parts of India.

A more accurate and rapid method for estimating true alcoholic strength of spirits in Custom Houses has been submitted to Government.

Extended tables for the reduction of spirits of any strength whose use will eliminate "shainkage wastage," and a "Technical Excise Manual" for the use of Excise officers in India by Colonel Bedford are under issue.

9. Drugs.—The question of a satisfactory test for samples of Indian hemp (*Cannabis sativa*) has again engaged the attention of the Director of the Central

Cannabis sativa.

Excise Laboratory. The case requires that the chemical method shall be closely correlated to results of physiological experiments, which latter have still to be made, and no satisfactory progress has been attained.

Peganum Harmala.

Before the Royal Society of Edinburgh last November Dr. James A. Gunn reported on "The Pharmacological Action of Harmaline." Harmaline is the more important of two alkaloids found in the seeds of *Peganum Harmala*, a plant which grows wild over a large area of Southern Europe, Egypt and Asia. The seeds were used medicinally by the ancient Greeks as they are to this day in India. Dr. Gunn finds that harmaline belongs to the group of protoplasmic poisons of which the best known alkaloid is quinine, and the actions of harmaline and quinine are practically the same, so that it is possible that harmaline may come to be used as a remedy for those diseases in which quinine is known to be effective.

Bassia longifolia.

An investigation has been made in the chemistry, biology and physiology of the soap-glucoside obtained from the seeds of *Bassia longifolia*. The results are communicated to the Journal of Bio-Chemistry, by B. Moore, S. C. M. Sowton, F. W. Baker-Young and T. A. Webster of the University of Liverpool. Mowrin is the name given to the bitter, irritant glucoside of the oil-cake. It is not poisonous to animals when eaten, but kills when injected. Hydrolysed with hydrochloric acid, it gives a gelatinous precipitate of mowric acid ($C_5H_8O_2$). Mowrin gave 3·1 per cent. of moisture, 14·4 per cent. of furfurol, 41·2 per cent. of dextrose and 40·1 per cent. of mowric acid. Injected into rats it causes paralysis of the limbs followed by respiratory failure resulting in death. The heart is not materially affected, there is nevertheless a fall in blood pressure. Mowrin is a powerful hemolytic agent.

Datura Metel.

The seeds of *Datura Metel*, a poisonous plant of the Punjab, have been examined by G. de Plato. The seeds are similar to those of tobacco, and while they contain, according to the author, neither alkaloids nor cyanogenetic glucosides, they contain allantoin.

Terminalia Arjuna.

The bark of *Terminalia Arjuna* is recommended in Hindu Materia Medica in heart disease, and Lal Mohan Ghosal of the Calcutta Medical College has submitted it to a chemical examination and physiological experiments. The drug contains sugar 17 per cent., tannin 12 per cent., a colouring matter, a body

glucosidal in nature, and 30 per cent. of ash most of which consisted of calcium carbonate.

The author, as the result of physiological experiments, proved that the drug is a cardiac stimulant, increasing the force of contraction and prolonging the diastole, at the same time it slows the heart, but it never acts as a complete cardial poison. It also acts as a powerful hæmostatic, the only drawback being the rise of blood pressure.

Boerhaavia diffusa.

The same writer has made observations chiefly of a physiological character on *Boerhaavia diffusa*, a herb largely used in Bengal in food and medicine. The author separated (1) an alkaloidal body, (2) an amorphous fat and (3) 15 per cent. of ash consisting of alkaline chloride and sulphates. It was shown that the active principle is a diuretic chiefly acting on the glomeruli of the kidney through the heart, increasing the beat and strength and raising the peripheral blood pressure in consequence. It has little or no action in respiration and on the liver its action is principally secondary.

Cucurbita Pepo.

Messrs. Power and Salway have examined the seeds of the common pumpkin (*Cucurbita Pepo*) which are regarded as an efficient and harmless tænifuge. The oil corresponded to 34·3 per cent. of the seed and consisted of the glycerides of linoleic, oleic, palmitic and stearic acids and a phytosterol. The seeds also yielded sugar, salicylic acid, resinous matter and a new monocarboxylic acid melting at 99°. Physiological experiments proved that the reputed remedial action of the seeds was not justified.

Cucurbita Citrullus.

The seeds of watermelon (*Cucurbita Citrullus* Linn.) have also been examined by Messrs. Power and Salway. The entire seeds yielded·19 per cent. of fatty oil consisting of the glycerides of linoleic, oleic, palmitic and stearic acids and a phytosterol. The seeds also contained soluble protein, resin, sugar and a new alcohol, cucurbitol. Physiological experiments with the resin showed that it was quite innocuous.

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FOREST CHEMISTRY, 1909-1910.

BY

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The following is the summary of the main results of the principal investigations conducted by the Chemical Department of the Imperial Forest Research Institute during the year under report.

Manufacture of Mangrove tannin extract. (*Rhizophera mucronata.*)

About three months of the year under report were taken up by the experimental manufacture of mangrove tannin extract, on a commercial scale at the Rangoon Tannin Factory. Besides the Assistant Forest Chemist's process for the decolorisation of mangrove extracts, three other processes were also tried in the factory and fairly large samples of the different extracts thus prepared were sent to some well-known European and American firms for practical trial. Out of the six reports received so far, four are fairly favourable. Some 15 more reports are awaited and it is expected that they will not only furnish the Research Institute with the required information regarding the exact market requirements, but will be of great help to the Forest Chemist in deciding the best method to be adopted for the treatment of mangrove bark.

Distillation of *Blumea balsamifera*, DC.

This investigation, which has been in progress for the last three years has been completed. The shade-dried leaves of Blumea balsamifera DC. of Burma were successfully distilled on a large scale in the Laboratory with the aid of the newly designed condenser referred to in the last year's report. The sample of the Blumea camphor thus extracted, was sent to Messrs. Schimmel & Co., Leipzig, through the Imperial Forest Economist for commercial valuation. The price quoted by them is so low that it would not be worth while to manufacture camphor from the *Blumea* of Burma as an industrial undertaking.

Distillation of *Rhusa* grass oil.

It has been found that steam distillation yields an appreciably larger percentage of the oil than the crude method of water distillation in vogue in the Central Provinces. Fairly large quantities of both the *Sofia* and *Motia* oils from both the varieties of the grass have been distilled in the Laboratory. Further investigation of the chemical composition of both the oils is in hand.

Mr. A. M. Arathoon, who owns a large shellac factory at Jhalda, Bengal, has evinced a considerable interest in the Assistant Forest Chemist's methyl alcohol process for the manufacture of shellac. He had a model shellac apparatus constructed according to the plan given in I. F. Memoirs, Vol. I, Part II, with a view to testing the economic value of the methyl alcohol process. The Assistant Forest Chemist was sent to Jhalda for a week in order to advise Mr. Arathoon on the working of the apparatus. Mr. Arathoon has expressed his opinion that he has no doubt regarding the commercial possibilities of the process and that it is of special use in the factory for the recovery of useful shellac from refuse lac.

Manufacture of shellac.

From the scientific reports on the samples of shellac manufactured by the methyl alcohol process, which have been received from England, it appears that this shellac is as good as if not better than the best shellac of the market. The commercial firms, however, report that the form* in which shellac was submitted to them was objected to by the trade, as the latter would appear to have taken a fancy to the extremely thin opaque cakes, similar to those in which the DC. brand of shellac is made up.

The commercial firms are thus of opinion that the shellac extracted with wood alcohol should be converted before export into such forms as are already well-known, otherwise it will have to be put on the market at considerably lower prices in the beginning than the best brands of shellac already exported from India.

A new model of apparatus for lac extraction is being constructed and it is proposed to make fairly large quantities of shellac in proper commercial form for exact valuation. In this apparatus use has been made of centrifugal force to separate by filtration dissolved lac resin from the sludgy impurities.

The analytical constants of shellac prepared by the methyl alcohol process, pure lac resin and lac wax were determined and a note embodying the results was communicated to the Society of Chemical Industry, London.

Shellac analysis.

The following table gives the constants for shellac, pure lac resin and lac wax as reported in the above note. The figures given in the table should be read for those given in the last year's report of the Board of Scientific Advice. The

A correction.

* The samples of shellac prepared in the Laboratory were in three forms: (1) fibrous of golden-yellow colour, (2) flakes of white to white-yellow colour produced by blowing air into the melted lac, and (3) thickish transparent cakes of yellow to brownish-yellow colour.

saponification values as reported last year are too high, owing to the use of a wrong factor by an oversight.

No.		Moisture.	Matter insoluble in hot alcohol.	Acid number A.	Saponification number B.	Ester number (B—A.)	Iodine absorption (Hubl.) after 18 hours action.	Endemann number.
		Per cent.	Per cent.					
1	Shellac from Kosum lac (Extracted by wood spirit.)	2·7	0·7	61·1	201·0	139·9	9·6	8·43
2	Shellac from Palas lac (Extracted by wood spirit.)	3·8	0·8	60·8	202·4	141·6	9·3	7·96
3	Shellac from Block lac (Extracted by wood spirit.)	3·9	1·1	63·1	201·6	138·5	8·2	9·16
4	Mirzapur Factory Shellac	2·0	0·6	64·4	203·6	139·2	8·6	7·39
5	Lac wax	...	...	22·1	79·2	57·1	8·8	...
		...	...	—24·3	—85·0	—60·7		
6	Lac resin (dessicator dry)	...	...	52·1	193·5	141·4	6·8	7·3
		...	...	—59·2	...	—134·3	—7·3	—8·2
7	Lac resin (melted and dried at 100° C.)	...	...	55·	190·0	135	10·6	...

Turpentine and Colophony.

The Turpentine oil produced in the Bhowali factory was not liked by the trade on account of the sticky residue left by it after evaporation. This defect was not completely remedied by the proposed partial redistillation of the oil. This can, however, be done by redistilling the whole of the first distillate, rejecting 20 per cent. of the total output of the crude oil. The loss thus incurred by the distillation is very heavy. The sticky residue in the oil, which is due to the presence of high boiling constituents in the latter could, of course, be easily obviated if the distillation of the oil were conducted at low temperatures under diminished pressure. But as this would have necessitated the use of costly vacuum apparatus, other devices had to be used for lowering the temperature of distillation. After various trials the Assistant Forest Chemist proposed to mix the crude oleo-resin

before distillation with a small proportion of low boiling medium such as acetic acid, methylated spirits, etc. He was sent to Bhowali in order to give his process a trial on a large scale. He succeeded in distilling the oil through methylated spirits at a considerably lower temperature than has been done hitherto. The greater portion of the oil was distilled below 100° C. According to the chemical analysis of the oil thus produced, it appears to be considerably superior to the oil hitherto obtained. The samples of the oil produced have been sent to different Indian firms for practical trial and their reports are being awaited. As regards the improvements in the manufacture of colophony, besides working out the processes of its decolorisation, a process of imparting to it a reddish tint as desired by certain shellac manufacturers has been successfully worked out. Samples of the articles thus prepared at Bhowali have also been sent to different Indian firms, for commercial valuation. Messrs. Hoare Miller & Co., of Calcutta, have reported very favourably on one of the samples, valuing it as equal to imported American colophony.

Canarium benga lense.

Attention was first drawn to this resin by the Reporter on Economic Products to the Government of India as an article of possible commercial value and it has been favourably reported on as a good shellac substitute by a London firm, provided its melting point could be lowered. A large sample of the resin received from the Forest Economist has been refined, and attempts are being made to produce samples with a sufficiently low melting point.

Camphor from *Cinnamomum glanduliferum*.

A sample of crude camphor distilled from *Cinnamomum glanduliferum* was received from the Forest Economist, which was refined and submitted to Messrs. Schimmel & Co., Leipzig, through the Forest Economist, for valuation. The sample has been favourably reported on by the said firm and is likely to fetch the same price as the Japan camphor. Further data as to the commercial possibilities of its distillation in India are being collected by the Imperial Forest Economist.

Refining of Koosam oil for soap-making.

A sample of Koosam (Schleichera trijuga *Willd*) oil sent in by the Imperial Forest Economist was refined for soap-making. The N.-W. Soap Co., which had reported unfavourably on the crude oil as a soap-making material, accepted the refined sample. Further data as to its commercial possibilities are being collected by the Imperial Forest Economist.

Publications.

PURAN SINGH . . Note on the Analytical Constants of pure Shellac, Lac resin and Lac wax. (Communicated to the Society of Chemical Industry, London, for publication.)

ASTRONOMY.

BY

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Solar physics.—Researches in solar physics are carried on under the direct control of the Government of India at Kodaikánal, the Director being Mr. Michie Smith and the Assistant Director Mr. J. Evershed. The chief instruments are:—

(*a*) A spectroheliograph made by the Cambridge Scientific Instrument Company, the object of which is that of making photographs of the sun using the light emitted by one chemical element only. In this apparatus a stationary image of the sun is made by a 12-inch triple-achromatic lens of 20-foot focus, fed by an 18-inch Foucault siderostat. Close up to the image and somewhat longer than its diameter is the narrow vertical slit of a spectroscope arranged in such a manner that the light which has passed horizontally through the collimating lens shall be deflected through two right angles by two prisms and a mirror, and shall so emerge from the camera lens parallel to its original direction. This light then falls upon another vertical slit which can be adjusted in such a position as to allow light of any desired wave length to pass through. In the Kodaikánal spectroheliograph the collimating and camera lenses, each of 5-inch aperture and 6-foot focal length, together with the prisms and slits, are attached to a rigid framework, while immediately in contact with the slit last described is a stationary photographic plate within a fixed camera. The rigid framework is capable of motion in a horizontal plane in such a manner that the primary slit may pass uniformly across the

image of the sun while the secondary slit will move at an equal rate across the sensitised plate; and as in each position an image will be formed at the second slit by light of the desired wave length and no other light can emerge, the result of the movement upon the plate is a complete image of the sun in monochromatic light. At present the H and K lines of calcium are largely used on account of the convenience afforded by the width of their absorption shading and the fact that the centre of the dark line is frequently 'reversed,' *i.e.*, is bright instead of dark, indicating that the calcium vapour is abnormally hot in the higher levels of the solar envelope. A photograph so obtained shows bright clouds—called 'flocculi'—of calcium vapour scattered about over the sun and gives a large amount of information that is not otherwise obtainable. Further, by causing the slits to move more slowly the exposure may be lengthened sufficiently to give photographs of the 'prominences' projecting from the sun's margin.

(*b*) Two 6-inch refractors, with one of which an Evershed spectroscope has been used since November 1904. These are used for visual examination of the sun and for spectroscopic study of spots and prominences.

(*c*) A spectrograph consisting of an 11-inch polar siderostat with a 6-inch Grubb lens of 40-foot focus. This is used with a 4-inch concave grating of 10-foot focus mounted on Rowland's plan, or a parabolic grating collimated to cure astigmatism, or a plane grating with collimator and camera lenses of 8-foot focus. A powerful spectrograph has also been erected in the spectroheliograph room, using a 3-inch plane grating. It is employed in photographing the ultra-violet region in spot spectra and in studies on the line of sight movement of the chromospheric gases. Both spectrographs have been fitted with special occulting shutters for regulating exposures in spot spectrum work.

(*d*) A photoheliograph by Dallmeyer. With this a photograph of the sun in ordinary light is made daily when possible. Originals are sent to Greenwich for the use of the Solar Physics Committee for those days for which photographs are not available from Greenwich or Dehra Dun.

(*e*) An 18-inch silver-on-glass parabolic mirror (the property of the Assistant Director) has been mounted in front of the 12-inch

photovisual lens in the spectroheliograph building. It has been found to be very efficient for photographing spectra, particularly in the violet region. The mirror is mounted in a box upon rollers in such a manner that during the operation of the spectroheliograph and associated instruments it may be pushed to one side so as not to obstruct the light incident upon the 12-inch lens. To bring it into use for photographing spot spectra, etc., the mirror and its mounting are run into position in front of the lens, with the centre of the mirror in the axis of the beam of light coming from the heliostat, an operation requiring a few seconds only.

(*f*) A powerful spectrograph has been set up on piers erected near the large mirror, and has been fitted with special arrangements for rotating the sun's image on the slit plate and for accurate guiding during long exposures on sunspots. The new Michelson 6-inch grating has been employed in this instrument, which has been largely used for photographing spot spectra, and limb and centre comparison plates.

(*g*) The Littrow spectroheliograph for photographing the sun's disc in Hα light is still incomplete although some promising trial plates have been obtained with it. Two large 45° prisms have been recently received from the Poona Observatory and these have now been mounted in the spectroheliograph. It is hoped to begin regular photographic work shortly.

2. **Routine work.**—In addition to the use of the spectroheliograph and photoheliograph the routine work includes visual examination of sunspots and faculæ, observations of widened and displaced lines in sunspot spectra and spectroscopic observations of prominences. A monthly article describing the solar activity is contributed to the "Monthly Weather Review," while for more technical purposes bulletins and memoirs of the observatory are issued. Of the former 20 have appeared, while of the latter the first has been published.

Photographs of spot spectra are now made in which different exposures are given for the spot and for the adjacent photosphere so that equally dense images of both spectra may be obtained: these are then copied and enlarged with a special apparatus so as to bring out clearly the characteristic features of the spot spectrum. Arrangements have also been made by which the slit of the parabolic grating spectroscope can be replaced by a

negative lens and enlarged images of sunspots obtained on a scale of about one metre to the sun's diameter.

3. **The Solar constant.**—Numerous photographs have been obtained of extra focal images of the moon reflected from a quartz mirror and for comparison similar images of the stars Regulus, Procyon, Rigel, Sirius and Capella. The apparatus has worked well and this method of detecting variation in the solar constant seems to be a promising one. Unfortunately the essential condition of a uniformly clear sky has been realized only in three lunations out of thirteen, *viz.*, in January, March and April.

4. **Spectroscopic investigations.**—A large number of high dispersion photographs of spot spectra have been obtained with the new Michelson grating and with the Rowland 3-inch grating. With improved arrangements for guiding and for rotating the sun's image on the slit plate, it is now possible to give the comparatively long exposures required in high dispersion work, keeping the slit accurately bisecting a spot in any required direction during the exposure. This is an essential condition for the study of problems connected with the movement of gases in sunspots.

5. **Radial Motion in sunspots.**—A study of the plates obtained has amply confirmed the results of the preliminary investigations. The spectra of all the larger spots which have appeared have been photographed, and the systematic line displacements in these indicate an accelerating outward radial movement parallel to the sun's surface of the gases in the reversing layer in every case. The movement measured varies from 1·3 to 3 km. per second at the outer limits of the penumbrae where the motion is greatest. A small component of motion at right angles to the radial movement has also been measured in spots favourably situated for detecting horizontal movements, that is, when not very far from the sun's limb. This probably indicates a spiral movement of the gases flowing outwards from the umbra of a spot—a slow movement of rotation superposed upon the radial motion. In all, 6 spots have been investigated for this movement, 3 northern spots and 3 in the southern hemisphere, and all have shown a movement of this kind of the order of 0·3 km. per second. It is found that the direction of motion is opposite in the two hemispheres; if it is really a rotational movement as seems probable then the direction of rotation is with the clock in the case of the three southern spots, and the reverse in the three northern. The rotational movement cannot as yet be affirmed however for an easterly or a westerly drift on the north or south side of a spot would equally satisfy the observations. The research is a

somewhat tedious one involving a large amount of the most accurate measuring work, but it is hoped that it may eventually throw light on the origin of the magnetic field in sunspots discovered by Hale.

6. **Radial motion in the Higher Chromosphere over spots.**—Photographs of the calcium lines H and K and of the hydrogen line C in spots have been made on all favourable opportunities. The central absorption lines of the broad bands H and K, and the hydrogen absorption line C in the solar spectrum are produced by absorption in the higher levels of the sun's atmosphere and it is of great interest to find that these lines are displaced systematically over sunspots in the opposite direction to the displacement of the lines of iron and other elements representing low levels. This shows that in the high levels there is a radial movement *inwards* towards the umbra from the outlying regions. The H and K lines are sufficiently well defined to admit of fairly accurate measures of the motion, which has been found to be of the same order of magnitude as the reverse movement of the low level gases. The average in 9 sets of measures is 1·83 km. per second near the outer limits of the penumbræ.

7. **Vertical movement in sunspots.**—When a sunspot is situated near the centre of the sun's disc the component in the line of sight of the horizontal radial motion becomes inappreciable. If, on the other hand, there is any vertical movement it is evident that the line of sight component will be near a maximum. With a view to detecting vertical motion measures are made of the lines in the spectra of all spots which have been photographed within 15° of the centre of the disc. The velocity of such motion is in all cases very small in comparison with the horizontal movements. Some preliminary results indicate a sinking movement in the umbræ of some spots amounting to 0·4 km. per second.

8. **Halley's Comet.**—During part of the months of April and May 1910, Halley's comet was very favourably placed for observation, and as photographs taken in India would fill a blank between those taken in America or Europe, it was considered advisable to take advantage of every opportunity to photograph the comet and its spectrum with such instruments as were available, or could be constructed in the observatory workshop.

The following is a brief summary of the results obtained with the different instruments:—

(1) A series of 45 plates was secured with a Grubb portrait camera permanently attached to the 6-inch equatorial in the north dome. These represent 23 days during the morning apparition

from April 18 to May 16 inclusive, and 6 days at the end of the month when the comet was an evening star.

(2) A series of 14 plates was obtained with a reflecting telescope fed by a cœlostat. They show the region of the comet's head and two degrees of the tail on a scale about twice that of the portrait lens. One plate only was exposed each morning so that 14 days are represented covering the period April 20 to May 16 inclusive.

(3) About 22 plates were obtained with small cameras from 5 inches to 11½ inches focal length, and show interesting features in the outer extensions of the tail.

(4) A series of 22 spectrum plates were obtained with a prismatic camera attached to the south equatorial between 18th April and 16th May inclusive. The main features shown in these are (1) a continuous spectrum due to the nucleus in which some of the Fraunhofer lines can be traced, indicating reflected sunlight; (2) A discontinuous spectrum of the gases surrounding the nucleus but not extending into the tail, and (3) a series of monochromatic images of the tail.

Extensive preparations were also made to observe the transit of the comet across the sun's disc on May 19 (civil time). Owing to the very great intensity of the cyanogen rays at wave-lengths 3281 and 3883 in the head of the comet it seemed probable that if the nucleus or coma could not be observed or photographed by ordinary methods on the sun's disc, it would appear as a dark absorption marking in spectroheliograph plates taken with the camera slit set on the line 3883. Unfortunately the weather was not very favourable for this work, but a few fairly good monochromatic photographs were obtained during the supposed time of transit of the comet. Neither these nor the direct photographs taken at the same time show any trace of the comet, nor could anything whatever be seen of the comet in the 6-inch telescope. The evidence as a whole although entirely negative is of importance in proving the extreme tenuity and transparency of the materials composing even the densest portion of the comet's head.

A bulletin has been issued (No. XX) giving detailed particulars of the work on Halley's Comet and the results of the measure of the lines in the spectrum plates. A more complete discussion of the spectrum has also been published in the monthly notices of the Royal Astronomical Society, Vol. LXX.

9. The observatory is now co-operating with the "International Union for Solar Research."

10. There is also at Poona, under the Government of Bombay, the Takhtasingji Observatory, where research in solar physics is carried on by Mr. Naegamvala. The chief portions of the equipment are :—

(*a*) A Foucault siderostat with an 8-inch image lens for use with a spectroscope which has recently been improved in England.

(*b*) An equatorial refractor with a Cooke 6-inch triple photovisual lens. This is provided with two 45° objective prisms, and a prominence spectroscope with a Thorpe transmission grating has been constructed locally for attachment to it.

(*c*) An equatorial reflector with a 20-inch mirror by Common. A focal plane ultraviolet spectrograph is now in complete adjustment and it is proposed to employ it for stellar spectra.

The twelve 'most widened' lines in sunspot spectra are observed daily and the results forwarded to Sir Norman Lockyer, and a close agreement is maintained with the observations made at South Kensington. The observatory is also co-operating with the International Union for Solar Research, and is observing the region 5300 to 5500 for all lines affected in sunspots.

11. **Solar Radiation.**—Of the three Angström pyrheliometers previously in use in Simla one was taken in January 1908 to the Solar Physics Observatory at Kodaikánal for employment there. The operation of these instruments in Simla and Kodaikánal is, however, difficult and intermittent on account of cloud and atmospheric dust.

METEOROLOGY.

BY

GILBERT T. WALKER, M.A., Sc.D., F.R.S.,

Director-General of Observatories.

The Upper Air.—In continuation of Mr. Field's experimental work with recording balloons, the purpose of which was shortly described in last year's report, 17 balloons with instruments were liberated by him at Jhang during the monsoon months of June and July, and 7 in December 1909; of the first set more than half were recovered, but only one of those in December. The heights reached during the monsoon ranged up to 12 miles, with a lowest temperature of about —107°F. and the descents occurred at

short distances from Jhang; in several cases within 10 miles of the starting point. The balloons in December all travelled eastward and their horizontal velocities indicated very high winds a few miles above the ground surface. The one instrument recovered had only reached the 6 mile level, with a lowest temperature of —35°F., but it came down as far away as Lahore. It appears probable that the remaining instruments, which would in the ordinary course have reached much greater altitudes, were carried into the Himalayas or Tibet, and that, but for some defect in the balloon which touched ground in Lahore, no one of the seven instruments would have been heard of again.

A feature of the ascents in the monsoon was the liberation on two occasions of a pair of instruments together on the same balloon with a view of comparing their records and ascertaining to how great an extent the traces could be relied upon to represent actual conditions. This question had assumed some importance in consequence of doubts which had been expressed by scientists at home as to the capabilities of instruments constructed so lightly as these must necessarily be. One pair was recovered and the two independent records were found to agree satisfactorily.

Attention was paid throughout the year to the training of a native clerk who had shown aptness in this work, with a view of enabling him to calibrate the instruments and liberate the balloons with native help only, in order that continuous systematic balloon work might be carried on from Jhang. This work has now been begun by the liberation of a series of pilot balloons, observed by two theodolites, the ascents taking place about five times a week. After obtaining skill at this preliminary work with pilot balloons the staff at Jhang are to begin liberating balloons with recording instruments, of which it is proposed that two weekly should be sent up in addition to three or four pilots.

Electrical Condition of the Atmosphere.—Following on the work done by Dr. Simpson in 1908 in relation to the origin of thunderstorms, a second series of observations on the electricity of rainfall was undertaken during the year 1909 with a view to confirm or amend the previous conclusions of which a statement was given in last year's report. The results of examination of the new data were published by the Royal Society in their Proceedings, and have since been included in a Memoir of the Meteorological Department which deals with the combined work of the two years and includes a consideration of the electrical condition of snowfall.

The automatic apparatus for recording the potential gradient in the atmosphere near the earth's surface was in nearly constant use, and the

apparatus for recording earth-air current, to which a reference was made last year, had been put into working order by the time Dr. Simpson left Simla to join the new Antarctic Expedition. It is expected that on his return Dr. Simpson will resume this piece of work, which was promising well at the time of his departure.

Correlation in seasonal variations of weather.—The application of statistical methods had previously shown that causal relationships exist between the monsoon rainfall of June to September in India and a number of factors as to which information is available at the beginning of June; and it appeared desirable to publish an account of the method with tables of the data on which it is based. The publication has been issued, and contains also attempts on similar lines to construct a method for forecasting Nile floods and the summer monsoon rains of Australia. In the former case it is shown that out of the 14 occasions since 1865 on which a forecast (based on the pressure in South Africa, the rainfall of Zanzibar and the accumulation of snow to the west and north of India) would indicate a departure of 10 per cent. or over, the departure is of the right sign 13 times: and the correlation co-efficient of the calculated departure with the actual is ·6. This co-efficient has the same value in the case of India, using 4 factors (South American pressure, Mauritius pressure, snowfall and Zanzibar rain), and of Australia, with 3 factors (Australian pressure, Indian monsoon rainfall, and Mauritius pressure).

Data from logs of ships in the Indian Ocean.—The collection of these has been continued, but it has not been possible to do any work upon them during the year.

Publications.—In addition to the Daily Weather Reports published at Simla, Calcutta, Bombay and Madras, the Monthly Weather Reviews, the Annual Summary, and various administrative pamphlets the following memoirs have been published departmentally:—

SIMPSON, GEORGE C. .	On the electricity of rain and its origin in thunderstorms. (*Mem. Ind. Meteor. Dept., xx, Part VIII.*)
WALKER, GILBERT T. .	On the meteorological evidence for supposed changes of climate in India. (*Mem. Ind. Meteor. Dept., xxi, Part I.*)
DITTO .	Correlation in seasonal variations of weather, II. (*Mem. Ind. Meteor. Dept., xxi, Part II.*)
SIMPSON, GEORGE C. .	Tables for the reduction of meteorological observations in India (*1910*).

TERRESTRIAL MAGNETISM.

BY

GILBERT T. WALKER, M.A., Sc.D., F.R.S.,

Director-General of Observatories.

Magnetic Observatories.—*Bombay* (*Alibag*).—The Bombay Observatory which was formerly maintained by the Local Government at Colaba was moved to Alibag in consequence of the introduction of electric trams into the city: it is now directly under the Government of India, the Director being Mr. N. A. F. Moos. The chief instruments are a set of magnetographs of the Watson pattern and a Schulze earth-inductor, in addition to ordinary magnetometers and dip circles. All have given satisfactory results through the year. A set of sight-reading instruments of Eschenhagen pattern has been ordered and will be used as a check on the Watson instruments as well as for special observations. The results of the sixty years of observations at Colaba are passing through the press.

2. *Dehra Dun, Kodaikánal, Barrackpore and Toungoo.*—These observatories were started as base stations in connection with the Magnetic Survey of India and are all equipped with Watson autographic instruments for declination, horizontal intensity and vertical force. Instead of dip-circles earth-inductors of the Schulze pattern have been set up at each place. Good results have been obtained through the year. At Dehra Dun, of the flooding of which mention was made last year, it is satisfactory to report that in spite of the heavy rain of this year, no break of record has occurred. The passage surrounding the magnetograph room was at one time flooded to a depth of 3 feet, but water was kept out of the room by a barrier at the door. In order to prevent this percolation of subsoil water the walls and floor of the observatory are now being plastered with portland cement.

3. The mean values of the magnetic elements for 1909 at the observatories are as follows :—

	Declination.	Horizontal force.	Vertical force.	Dip.
Bombay . .	1° 0′·3 E.	·36845	·16033	23° 30′·0
Dehra Dun .	2° 34′·8 E.	·33276	·31909	43° 48′·0
Barrackpore .	1° 0′·7 E.	·37300	·22099	30° 38′·7
Kodaikánal	0° 50′·1 W.	·37459	·02391	3° 39′·1
Toungoo .	0° 30′·0 E.	·38766	·16475	23° 1′·5

An error in the mean values of H. F. and Dip at Barrackpore for the year 1908 has been discovered owing to the wrong temperature having been taken for the correction of the measured ordinates. The correct mean values are ·37298 and 30°34′·6.

4. **Magnetic Survey.**—The general scheme was to execute a preliminary survey of the whole country and a detailed survey of those areas where, owing to local irregularities, further information was required. The preliminary survey was to consist of observations of declination, intensity and dip at about 1,100 stations, and measurements were to be made in successive years at about 22 'repeat' stations in order to effect the elimination o secular variation.

Field work was begun in November 1901 and up to the end of the year 1908-09 1,255 field stations had been occupied and 23 repeat stations established, in addition to 24 stations on the Seistan trade route where declination had been observed; observations had also been repeated at 57 old field stations. In the detailed survey 122 stations had been occupied.

During the field season under report four detachments were employed. Of these one worked in the outer ranges of the Himalayas from Naini Tal to Dalhousie, two re-observed at most of the old field stations in the area lying between Lat. 16°-19° and Long. 73°-78° where the secular change in H. F. appears to be particularly abnormal, and also examined a few small areas in detail, while the fourth was employed on detail survey in Central India.

5. The officer in charge, Captain R. H. Thomas, R.E., with his assistant Lieutenant H. T. Morshead, R.E., re-observed at all the repeat stations (with the exception of Port Blair) and also at a number of old field stations. Comparative observations were made at the four survey base stations and also at Alibag.

Full sets of magnetic observations were taken at 69 new and 71 detailed survey stations while 100 old field stations were re-occupied.

6. During the recess season the investigation of the question of instrumental differences in H. F. has been continued and has necessarily postponed the discussion of other results obtained during the working season. The investigation, however, is nearing completion and it is hoped that satisfactory results will be obtained.

The standard instruments are liable to some unknown change which produces an apparent drop in the moment of the magnet and an apparent change, usually an increase, in the value of the horizontal force. That this change is not a permanent one is indicated by the fact that in May

1908, immediately after a large drop in the moment of the Dehra Dun standard magnet, No. 17, the differences of all the field instruments from the standard dropped by about 20γ, while at the next comparison in October 1908 these differences had resumed their original values, and the base line of the Dehra Dun magnetograph, after rising suddenly in May, dropped rapidly during the next 4 or 5 months.

There also appears to be some evidence of personal error between observers. The clearest case of this is at Kodaikanal where one observer took over the duties of the permanent observer for three months. Immediately after this change m_o dropped 0·46 C.G.S. units and the base line 19γ, a rise of exactly the same amount occurring when the permanent observer returned. This was a simple case and can easily be allowed for, but in other cases of change of observers the evidence is not so clear and it is difficult to decide whether any correction should be applied.

In addition to this investigation the ordinary computation of the field work and the reduction and tabulation of the base station results for 1909 has been undertaken and is nearing completion.

7. For the next field season a magnetic survey of the Andamans and Nicobar Islands is proposed and also a detailed examination of the coal fields of Bengal. Besides this a number of old field stations will be permanently marked to admit of their re-occupation in the future.

GEOLOGY.

BY

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Late Officiating Director, Geological Survey of India.

CONTENTS.

INTRODUCTION.

This report contains a summary of the operations conducted by the Geological Survey of India during the calendar year 1909. In certain cases the results of these operations have already appeared in the publications of the Department, and these are only briefly referred to here. The work still in progress in Rajputana and in Burma is, however, not yet completed, and is accordingly described in somewhat greater detail.

PETROLOGY.

Rocks from Gwalior and Alwar.

2. A large number of petrographical determinations have been made by Mr. Jones of the rocks collected by him in the Gwalior State, and by Mr. Heron of the Alwar rocks, but no types of particular interest have been found among them. A general account of these rocks is given in the section on Geological Surveys below (pp. 69, 70).

Rocks of the Aden Hinterland.

3. Mr. Vredenburg has worked out the petrology of the rocks collected by Captain R. E. Lloyd, in the hill country north of Aden (*see* below, p. 63). The assemblage of specimens from the older volcanic series, resembling that of the Upper Cretaceous formation in Baluchistan and Persia, together with their superposition upon the Jurassic rocks, leaves little doubt that they belong to the same period of volcanic activity as the Deccan trap. The acid varieties are represented by rhyolitic lavas, rhyolite breccias and ash beds, and there are also some doubtful andesites. Among the basic rocks there are dolerites with beautiful pleochroic augites of purple colour; a dolerite closely resembling many of the dyke rocks of Deccan trap age occurring in Baluchistan; ordinary basalts without olivine, also resembling the Deccan trap; basalts with olivine, and an abnormal rock made up of a base composed of small prismatic crystals of augite, iron ores, and serpentinous material, through which are scattered vacuoles filled with felspar and epidote; and olivine porphyry. Geodes of agate, chalcedony, jasper, etc., are extremely common in the basalts, and may be picked up in large quantities on the surface as in the Deccan trap areas in India. Mr. Vredenburg's notes are published in Vol. XXXVIII, Pt. 4 of the *Records*.

PALÆONTOLOGY.

Upper Jurassic fossils from the Aden Hinterland.

4. The collections of fossils made by Captain R. E. Lloyd in the hill country north of Aden have been examined by Mr. Tipper, whose notes on them are published in Vol. XXXVIII, Pt. 4 of the *Records*.

They consist of a Belemnite, *B.* cf. *tranganensis* Futterer; four species of *Perisphinctes;* an undetermined gasteropod closely resembling *Dicrolema* (*Pietttia*) *seminudum* Heb. and Desl.; among lamellibranchs *Parallelodon egertonianum* Stol., and species of *Pinna, Trigonia, Pecten* (*Syncyclonema*) and *Cardinia ?*; and a species of *Pentacrinus.* Mr. Tipper considers that the fauna described possesses a distinctly Upper Jurassic facies.

Fusulinidæ from Afghanistan.

5. In a paper contributed to the *Records* (Vol. XXXVIII, pt. 3), Mr. Hayden has given a description of various *Fusulinidæ* collected by him in the limestones of the Bamian valley in Afghanistan. The material described consists chiefly of well-known forms and includes *Fusulina uralica* Krotow, *F. elongata* Shumard, *Schwagerina princeps* Ehr., *Neoschwagerina craticulifera* Schw. and *N.* (*Sumatrina*) *annæ* Volz. A new species, *Neoschwagerina primigena,* is described, intermediate between *Schwagerina* (*Doliolina*) *lepida* Schw. and *N. craticulifera,* and the last named fossil is shown to be dimorphic.

Mr. Hayden also made a critical examination of the nature of the shell of the *Fusulinidæ,* which he found to be composed of cryptocrystalline material identical in structure with the shell-substance of the *Porcellanea* and he pointed out that certain authors had mistaken the dark shell-wall for perforations and *vice versâ.* At the time of writing his paper, he had not seen the very important memoir by Professor Douvillé, which had previously appeared in the *Bulletin de la Société géologique de France;* he was not aware, therefore, that the latter author had come to the conclusion that the so-called perforations of *Fusulina* were in reality gaps in a net-work of varying degrees of fineness, and that this net-work was covered by a thin imperforate layer, to which attention had already been drawn by Girty. In Mr. Hayden's specimens the gaps in the net-work ('perforations') are frequently seen to traverse this outer layer, which therefore appears to be 'perforate.' It is of course possible that this may be due to the state of preservation of the specimens and, with a view to deciding this, Mr. Hayden is at present in correspondence with M. Douvillé on the subject.

Fossil fish teeth from Burma.

6. Mr. Murray Stuart has described and figured a number of fossil fish teeth, collected from various localities in Burma, in Vol. XXXVIII, Pt. 4 of the *Records.* The evidence afforded by these is in favour of the classification of the Tertiary strata in Burma put forward by him in the paper noticed below (p. 110).

Ostrea latimarginata in Burma.

7. Messrs. Vredenburg and Stuart describe in Vol. XXXVIII, Pt. 2 of the *Records* the occurrence of *Ostrea latimarginata*, a species characteristic of the Gaj groups of Kachh and Sind, in the Yenangyaung Stage of the Pegu System in Upper Burma. The fossil was discovered by Mr. H. J. Davies, Geologist to the Burma Oil Co., and throws much light upon the vexed question of the correlation of the Tertiary rocks in Burma. Mr. Stuart considers that the Kama clay, which occurs immediately above the zone of *O. latimarginata*, must represent a part of the 'Hinglaj beds' of Mekran, as defined by Mr. Vredenburg, and confirms the suggestion that a distinct unconformity separates this Kama clay from the base of the Irrawaddy System. This observation is of importance, as it accounts for the extreme divergence in the thickness of the Kama clay which, as recent surveys have shown, constitutes the main petroliferous horizon in Burma; whereas Dr. Noetling considered that at Yenangyaung the oil sands occurred at a lower horizon, *i.e.*, in the Lower Prome beds of Mr. Theobald (*see* below, p. 110).

Hippurite-bearing limestone in Seistan.

8. Mr. Vredenburg has described, in *Records*, Vol. XXXVIII, Pt. 3, two interesting species of *Hippurites* from a collection made in Seistan by Mr. T. R. J. Ward and Sir Henry McMahon, and gives in the same paper a geological sketch of the country. The two species of *Hippurites* described are *H. gosaviensis* Douvillé and a new species *Pironæa persica* Vred., and Mr. Vredenburg considers the beds to be most probably uppermost Turonian. A large ribbed bivalve, which Mr. Vredenburg was unable to identify at the time his paper was written, has since been shown by Dr. Emil Böse of Mexico to be a species of *Chondrodonta*, a genus distinguished by the peculiar interlocking chondrophores of the hinge and associated with shells of the Rudistæ in Europe and America. Mr. Vredenburg has consequently given the name of *Chondrodonta Bösei* to the Seistan species.

New Tertiary Mammalian genera and species.

9. As a result of the exploration of the Tertiary ossiferous deposits of India now being carried out by Dr. G. E. Pilgrim, with the assistance of Sub-Assistant M. Vinayak Rao, it has been found necessary to establish several new genera and species of mammals. A preliminary list of these is published to the present volume of the *Records*, Pt. 1, and full descriptions of those forms which have been determined up to the present are now in the press.

Trias of the Himalaya, Dr. C. Diener.

10. The examination of the Triassic fossils from the Himalaya collected at various times by the late Mr. C. L. Griesbach, the late Dr. A. von Krafft, Dr. Diener, Mr. Hayden and others has now been completed, and Dr. Diener has summed up the whole question of the distribution and correlation of the Triassic rocks in the four distinct areas from which the fossils have been obtained, *viz.*, Painkhanda, Spiti, Eastern Johar and Byans, and the exotic blocks between Malla Johár and Hundes, in an exhaustive paper which will shortly appear as Vol. XXXVI, Pt. 3 of the *Memoirs*.

The more recent researches of Hayden and von Krafft have shown that the Trias is not developed uniformly throughout the Himalaya, and that there is no 'type section' to which the development of the system in various localities can be referred. Thus the present memoir supersedes the summary of the Trias of Asia, so far as the Himalaya is concerned, published by Dr. Noetling in the *Lethœa Mesozoica* (Vol. I, 2, Stuttgart, 1905). The Triassic beds of the Himalaya were divided by him into ten cephalopod-bearing horizons thus:—

Upper Trias.	10. *Sagenites* beds. 9. *Halorites* beds. 8. *Hauerites* beds. 7. *Tropites* beds. 6. *Joannites* beds.
Middle Trias	5. *Ptychites* beds. 4. *Robustites* beds.
Lower Trias	3. *Stephanites* beds. 2. *Hedenstræmia* beds. 1. *Prionolobus* beds.

The base of the Trias was drawn above the *Otoceras* horizon, which Griesbach considered to be a passage bed between the Permian and Trias. It is now shown, however, that *Oteceras* is confined to a thin layer at the base of the Lower Trias.

The sub-division of the whole system now adopted by Dr. Diener is shown in the following table, which also indicates the variations that occur in the three principal areas from which collections have been made :—

Spiti.	Thickness.	Painkhanda.	Thickness.	Byans.	Thickness.	Equivalents in the Eastern Alps.		
Megalodon limestone.[1]		Megalodon limestone.		Megalodon limestone.		Upper.		
Quartzite series (*Spirigera Maniensis*)	Feet. 300	Quartzite series (*Spirigera Maniensis*)	Feet. 250		Feet.	Middle.	Noric Stage.	Upper Trias
Monotis beds (*Monotis salinaria*)	300	Anodontophora Griesbachi beds (Sagenites beds)	160	Greenish black shales with sandy bands.				
Coral limestone (*Spiriferina Griesbachi*)	100	Limestone with *Spiriferina Griesbachi*	320		1,000			
Juvavites beds	500	Halorites beds, Nodular limestone with *Proclydonautilus Griesbachi*	200			Lower.		
Dolomitic limestone (*Lima* cf. *austriaca*)	300	Beds with *Halobia comata*.	800	Tropites limestone.		Tuvalic.	Carnic Stage.	
Tropites shales (*Tropites* cf. *subbullatus*)	600							
Grey beds. Higher beds with brachiopods and bivalves, near base *Joannites cymbæformis*	500			Grey, massive limestone.		Julic.		
Halobia limestone (*Halobia comata*)	150	Traumatocrinus limestone	25	*Ceratites Thuillieri Spiriferina Stracheyi.*		Cordevalic.		
Daonella limestone. Higher beds with *D. indica*, near base *D. Lommeli*	150	Passage beds of the Shalshal Cliff	10-20	Limestone with *Rhynchonella Griesbachi.* Near top *Sibirites spiniger.*	250	Ladinic stage.		Middle Trias
Daonella shales (*D. Lommeli*)	160							
Upper Muschelkalk (*Ptychites rugifer*)		Upper Muschelkalk (*Ptychites rugifer*)			...	Muschelkalk.		
Beds with *Spiriferina Stracheyi* and *Keyserlingites Dieneri*		Beds with *Spiriferina Stracheyi* and *Keyserlingites Dieneri*						
Niti limestone[2] Shaly bed with *Rhynchonella Griesbachi*	100	Niti limestone. Shaly bed with *Rhynchonella Griesbachi*	100					
Hedenstræmia beds (*Flemingites Rohilla*).		Hedenstræmia beds (*Flemingites Rohilla*)				Campil beds.		
Meekoceras beds (*Meekoceras Varaha*)	40	Meekoceras bed (*Meekoceras Markhami*)	...	Chocolate limestone.	150	Seis beds.		Lower Trias
Ophiceras bed (*Ophiceras Sakuntala*)	...	Otoceras beds (*Otoceras Woodwardi, Ophiceras Sakuntala*)	...					
Otoceras bed (*Otoceras Woodwardi*)	...							
Kuling shales	...	Kuling or Productus Shales		Kuling or Productus Shales.	...	Permian.		

[1] In the classification now employed by the Geological Survey of India, this term has been discarded for Stoliczka's original name "Para" (see Burrard and Hayden, Geology and Geography of the Himalaya, p. 289.

[2] "Nodular limestone" of the Geological Survey of India classification.

Fifteen cephalopod-bearing horizons are distinguished by Dr. Diener, as shown in the following table. Of these three are rather doubtful, No. 5

being perhaps not an independent palæontological horizon, though *Rhynchonella Griesbachi* is confined to it; while from 9 only a single ammonite is known, *Joannites thanamensis*, and No. 15 is based on two fragmentary specimens of ammonites :—

	Spiti.	Painkhanda.	Byans.	Exotic blocks of Chitichun and Malla Johar.
Noric stage.	15. Horizon of *Trachypleuraspidites* aff. *Griffithi*. 14. Horizon of *Juvavites angulatus*.	15. Horizon of *Sagenites* sp. ind. 14. Horizon of *Halorites procyon*. 13. Horizon of *Proclydonautilus Griesbachi*.		
Carnic stage.	12. Horizon of *Tropites subbullatus*. 10. Horizon of *Joannites cymbæformis*. 9. Horizon of *Joannites thanamensis*.	12. Horizon of *Mojsvarites eugyrus*. 11. Horizon of *Juvavites tonkinensis* and *Hypocladiscites subaratus*. 10. Horizon of *Joannites cymbæformis*.	14. 13. 12. } Horizon of *Tropites subbullatus* and *Halorites* sp. aff. *procuon*.	12. 11. } Horizon of *Cladiscites crassistriatus*.
Ladinic stage.	8. Horizon of *Protrachyceras Archelaus*.			
Muschelkalk.	7. Horizon of *Ceratites Thuilleri* and *Ptychites rugifer*. 6. Horizon of *Keyserlingites Dieneri*.	7. Horizon of *Ceratites Thuilleri* and *Ptychites rugifer*. 6. Horizon of *Keyserlingites Dieneri*. 5. Horizon of *Sibirites Prahlada*.	7. Horizon of *Ceratites Thuilleri*.	6. Horizon of *Monophyllites Confucii*.
Lower Trias.	3. Horizon of *Hedenstræmia Mojsisovicsi* and *Flemingites Rohilla*. 2. Horizon of *Meekoceras Varaha*. 1. Horizon of *Otoceras Woodwardi*.	3. Horizon of *Hedenstræmia Mojsisovicsi* and *Flem. Rohilla*. 2. Horizon of *Meekoceras Markhami*. 1. Horizon of *Otoceras Woodwardi*.	4. Horizon of *Sibirites spiniger*. 3. Horizon of *Hedenstræmia Mojsisovicsi*.	3. Horizon of *Meekoceras Joharense*.
Permian	Horizon of *Cyclolobus insignis*.			

The Lower Trias and Muschelkalk are developed almost equally well in Spiti and Painkhanda, but in Byans both divisions are not so well represented. In this area, however, the topmost beds contain the fauna of the *Sibirites spiniger* zone, which is probably homotaxial with that of the Upper Ceratite Limestone of the Salt Range.

In the ladinic stage a strongly marked difference in the development sets in. It is much richer in fossils and of greater thickness in Spiti than in Painkhanda, and has not yet been traced further east.

The same difference is equally prominent in the carnic deposits, which are well developed in Spiti, but are almost insignificant in Byans.

The noric deposits are divided into three sets of beds—Quartzite series, Brachiopod beds and Cephalopod beds—of which the last named are locally very rich in fossils, but do not form a constant stratigraphical horizon. The lower noric beds of Byans show peculiar features, being made up of black shales of great thickness, wanting in the other districts. The upper noric beds consist everywhere of thick limestones which pass through beds of doubtful age into limestones of Middle Jurassic age, overlaid by the Upper Jurassic Spiti Shales. The base of these is marked by a very constant ferruginous oolitic layer of Kelloway age.

11. Dr. Diener appends to his memoir a discussion of the extension into other regions of the Indian Triassic province. He shows that the Triassic strata were deposited along the southern shore of the ancient ocean known as *Tethys;* that the fauna bears a quite distinct character which distinguishes it from those of the Mediterranean region; and that during the middle and upper Triassic periods Afghanistan was at the western limit of the province. Eastwards, on the other hand, the fauna of Himalayan type has been found in Yunnan, but that of Tongking points to a closer connection with the eastern Pacific region. To the south-east, however, the Indian marine Trias has been traced through the Malay Archipelago; and this region appears to have formed a connecting link between the Indian and Pacific provinces; while evidence of the extension of Himalayan elements to New Caledonia during this period has recently been obtained. So close that Dr. Diener states that "the Trias of this island can scarcely put in a claim for being separated from the Indian Triassic province as a special faunistic district."

The memoir concludes with a brief account of the evolution of the Triassic ammonites.

PHYSICAL GEOLOGY.

Himalayan glaciers.

12. During the year 1906 a number of glaciers in the North-West Himalaya were visited by officers of the Geological Survey and permanent marks were affixed to the rocks near their lower ends in order that observations on their secular oscillations might be made in future years.

Alukthang and Zemu glaciers in Sikkim.

This work was carried out at the instance of Mr. D. W. Freshfield, on behalf of the *Commission Internationale des Glaciers*, and has now been completed for the present by the demarcation of two of the glaciers descending from the Kinchinjunga Group in Sikkim. The observations recorded are published in Pt. 1 of the present volume of the *Records*. Marks have now been placed at, and plane table plans made of, the ends of 14 glaciers, extending from Kashmir through Lahaul and Kumaon to Sikkim.

Hassanabad glacier in Hunza.

13. An interesting letter has been received from Dr. Hunter Workman giving an account of a visit in June 1908 to the Hassanabad glacier in Hunza, one of those marked by Mr. Hayden in 1906 (*Records*, Vol. XXXV, Pt. 3, p. 185). One of the boulders marked No. 3 in Mr. Hayden's plan (op. cit. Pl. 38), had slipped down the hill some 50 or 60 feet from its former position, but Nos. 1 and 2 were *in situ*, and the inscriptions still bright and clear. Dr. Hunter Workman states that the tongue of the glacier had remained stationary since the plan was made, and had not altered appreciably in appearance.

Kashmir glaciers.

14. Dr. A. Neve, of the C. M. S. Mission, Kashmir, has sent us some interesting notes on the Murgisthang or Mongstong glacier in the Mustagh Range, and on the Machai (or Mechoi) glacier, near the crest of the Zoji La, on the road from Srinagar to Leh. The latter is one of the most easily accessible glaciers in Kashmir, but the ice is so buried in moraines on either side that it would be difficult to find spots on which permanent marks could be placed near the tongue. Dr. Neve thinks that there has been scarcely any change in it during the last 25 years.

The Khumdum glaciers.

15. The Khumdum glaciers are situated on the right bank of the Shayok river near its source, and were visited in 1908 and again in 1909 by Captain D. G. Oliver, I.A., accompanied on the latter occasion by Dr. T. G. Longstaff.

The chief interest of these glaciers, so far as the question of secular oscillation is concerned, lies in the fact that they all descend from lateral valleys to the bed of the river, along which runs an important trade route across the Karakoram Pass into Tibet. Thus any general retreat or advance of the ice can be easily recognised. Captain Oliver gives instances of floods caused by the advances of the glaciers completely across the bed of the river, the last occasion when this happened being 1903. The Aktash glacier also advanced in the same manner in 1905, but caused no flood, as the water percolated through sand in the river bed at this point.

Dr. Neve's and Captain Oliver's notes will shortly be published in the *Records*.

Lakes of the Punjab Salt Range.

16. While engaged on a traverse along the plateau of the Salt Range in the Punjab, for the purpose of ascertaining the probable extension of the coal seams beneath the Nummulitic limestone, I took the opportunity of surveying and taking soundings of the four permanent lakes found on the plateau. The basins of these lakes with the exception of the Jalar Kahar, were found to owe their origin to earth movements, that is to say, to a synclinal fold in the case of the Kabaki Kahar and to faulting in that of the Kalar and Son Sakesar Kahars respectively. The Jalar Kahar has been formed by erosion along the crest of an anticlinal fold in carboniferous limestone. All the lakes are very shallow and none of them has any visible outlet. Their present configuration is due to irregularities in the accumulation of wind-blown 'loess,' which collects in the original depressions. A full account of the lakes is published in Part 1 of the current volume of the *Records*.

Mud volcanoes of the Arakan Coast.

17. In a paper published in Vol. XXXVII, Pt. 3, of the *Records*, Mr. Coggin Brown brought up to date the accounts of the various eruptions of the mud volcanoes situated off the Arakan Coast that have taken place since 1893. There appears to have been a remarkable period of quiescence between the years 1886 and 1903, similar to that noted by Mr. Mallet between 1846 and 1878, but it is not certain that the apparent falling off in activity is not due to lack of evidence of eruption. Since 1903 five eruptions have been recorded and are described by Mr. Brown, one of which resulted in the formation of a new island, off Beacon Island, on the 15th December 1906. This island was still in existence in December 1908, but a great part of it had been washed away.

ECONOMIC ENQUIRIES.

Coal.

Revision of the map of the Raniganj coal-field.

18. The revision of the geological map of the Raniganj coal-field, undertaken in November 1908 in conjunction with a Committee appointed by the Mining and Geological Institute of India, has made fair progress, and it is hoped will soon be completed. The re-survey is being carried out on behalf of the Geoglogical Survey Department by Mr. H. Walker, who testifies to the general accuracy of the original maps, for a long time out of print, constructed by the late Dr. W. T. Blanford in 1858-1860 ; only minor corrections in the boundaries along the margin of the field, where dense jungle existed in Dr. Blanford's time, being necessary. The principal additions to our knowledge of this important area have been made with respect to the underground correlation of the coal seams and the more accurate mapping of faults and dykes in which work Mr. Walker and the Committee have received most valuable assistance from the owners and managers of the collieries, most of whom have placed their mining plans and boring records freely at their disposal.

Gilhurria, Rajmahal Hills.

19. A small patch of Damuda rocks at Gilhurria on the western flanks of the Rajmahal Hills, containing a seam of combustible carbonaceous shale, was examined by Mr. Stuart in the course of his examination of the area for china-clay and glass-making sands (referred to in last year's General Report) and is described in a short paper in Vol. XXXVIII, Pt. 2, of the *Records*. The occurrence is interesting, as it indicates the continuance of the Damudas of the Hura and Dhamni coal-fields beneath the trap, but the coal, which was being quarried by the natives, is of poor quality at the outcrop.

Punjab Salt Range, Shahpur District.

20. At the instance of the Railway Board, I was deputed to visit the coal mines being worked by native owners in that part of the Punjab Salt Range which lies in the Shahpur District, as application had been made for the construction of a branch line from Dhak station on the Sind-Sagar line to the foot of the range to serve the mines. At present the mines are worked entirely from the outcrop, and no attempt has been made to form a reliable estimate of the quantity of coal available. The present output is not more than 40 or 50 tons a day, and until more capital is spent on the development and equipment of the mines, it would be premature to discuss the question of constructing a branch line to the locality, unless there is a demand for building stone from the Range sufficient to supplement the coal traffic.

I also made a traverse along the Salt Range plateau and suggested that a series of borings should be put down through the Nummulitic limestones which cover the greater part of it, in order to ascertain whether coal exists in workable quantities beneath it at the horizon at which the coal seams crop out along the southern scarp. An experimental boring at Dandot was sanctioned for the purpose of estimating the cost of carrying out this scheme, and is now in progress.

Sikkim.

21. Reports of the discovery of coal in the valley of the Great Rangit River in Sikkim having been received, I visited the localities during my tour in that State. Several of the outcrops had been opened out sufficiently to show that the so-called coal is a dense black carbonaceous shale, so greatly crushed as to have assumed a nodular structure in which the nodules are surrounded by a thin glistening film of carbon, the appearance in bulk being that of a hard bright coal. It is so impure, however, that when placed on a fire it merely becomes calcined, and it will not support combustion. Some of the seams are as much as 6 feet in thickness, but none of the so-called coal is of any value as fuel.

Copper.

Sikkim.

22. On my way to the glaciers of Kinchinjunga I also visited the localities in Sikkim at which copper ores are known to occur, and are now being actively prospected under European supervision. The conditions under which the lodes occur, especially the intense folding and dislocations to which the rocks have been subjected, render it extremely difficult to form a definite opinion regarding the continuation of any particular occurrence of ore, but it is evident that in many cases the lodes, though perhaps originally continuous, have been broken up into a succession of small detached lenticles or pockets, and that the location of these would be a matter of great difficulty and expense. In a few instances, however, lodes of some persistence have been opened up, and may prove to be worth exploitation by modern methods.

Gwalior.

23. Traces of copper ores in the Bundelkhand gneiss of the Gwalior State were investigated by Mr. Jones (*see* below, p. 113), but were found to be of no economic importance.

Engineering Questions.

Building sites at Dalhousie.

24. At the request of General C. H. Powell, Commanding the Jullunder Brigade, I visited the Hill station of Dalhousie in September for the purpose of examining the sites proposed for the erection of a garrison church and other buildings. The cantonment is situated on a narrow spur known as the Balun spur which runs out to the north from the high ridges on which Dalhousie itself is built, at a considerably lower level than the civil station. This spur consists of slates which have a regular easterly dip, corresponding very closely with the slopes on the eastern side of the spur. The soil cap on this side, which is of great thickness, has therefore a constant tendency to creep downwards, as the toe of the slope is cut away by the stream at its base, and any heavy structures, either on the slope or near its crest, are liable to serious movement of their foundations. In fact every building already erected in such a position is severely cracked, and the eastern end of one of the barracks, which are exceedingly massive, had to be pulled down some years ago. These movements are, however, entirely confined to the soil cap, and all buildings erected not too near the eastern edge of the spur would be perfectly safe. Such a site was selected for the church and the other buildings to be erected.

Cauvery River Project, Coimbatore District.

25. In response to a request made by the Chief Engineer for Irrigation in Madras that the sites proposed for a dam on the Cauvery River in the Coimbatore District should be inspected and reported on by a Geologist, Mr. H. Walker was deputed on this duty in July 1909. Five sites in all were examined, situated on a straight reach of the Cauvery between Cauveripuram and the mouth of the Bhavani River, where it is bordered on either side by hills of crystalline rocks. Mr. Walker submitted a full report to the Local Government, and was able to recommend a site about 8 miles below the village of Sanpalli as the most suitable for the project, but details of alternative sites are given, the final choice depending upon economic and engineering considerations.

Fire clay.

Gwalior State.

26. Among the clay beds at the base of the Morar group in Gwalior State a thick bed of soft white clay near Raipur G. T. S. has been extensively mined for use as whitewash, but from its composition, and from tests made by Mr. H. C. Jones, it is considered that it would make good fire bricks.

Galena.

Gwalior State.

27. Mr. H. C. Jones examined some occurrences of galena in the Gwalior State at the request of the Durbar. Mere traces of the existence of the mineral were found, as described below (p. 70).

Petroleum.

Oil-fields Committee, Yenangyaung.

28. At the beginning of the season Mr. E. H. Pascoe was engaged in assisting the Committee appointed to enquire into the working of the Yenangyaung oil-field. An analysis of data regarding flash-points and specific gravities supplied by the Burma Oil Co., led to the following interesting conclusions :—

(*i*) That in each well the specific gravity decreases generally with the depth, especially near the surface.

(*ii*) That in each oil horizon the specific gravity is generally least at the crest and increases further down the flanks of the anticline. Wells therefore near the margin of the field may be expected to yield a heavier oil at any particular horizon than those nearer the crest.

A final attempt was made to correlate the various oil sands recorded in the boring logs of the Companies engaged in the industry, but was not successful.

Ramri Island. Mr. E. H. Pascoe.

29. The portions of Ramri Island, off the Coast of Arakan, examined were the northern area including the Minbyin oil-field (Yenandaung) and the oil-field of Ledaung. The island is evidently part of a raised archipelago and raised beaches are found all along the West Coast. The rocks consist of sandstone and clays with occasional thin bands of conglomerate. Calcite is abundant locally, but selenite was not found in the portions of the island visited. From Mr. Davies' find of nummulites near Pyade, some of the rocks appear to be of Eocene age. Mr. Pascoe was no more successful than Mr. Mallet in any attempt to divide the beds into distinctive series.

In all but one or two doubtful cases, the rocks are inclined steeply or vertically, and the hypothesis which fits in best with the facts is that there are several sharp contiguous folds which have been sufficiently denuded to leave an almost uninterrupted series of steep dips. Some of the folds are very sinuous, and the direction of dip and strike may vary enormously.

Mud volcanoes, gas vents and oil seepages are found throughout the island, except within a barren tract around the town of Ramri.

In the Minbyin field native workers have shewn themselves more enterprising than those at Yenangyaung, and have adopted a crude method of the rod-system used in Canada, learnt from Canadian drillers employed by the Australian and Baronga Oil Companies. The wells are cased for the first 18 to 20 feet only, and are never more than 500 feet deep. Some 200 wells have been put down here but most of these have been abandoned, less than 50 being worked at the present day. The total yield of the field amounts to something under 2 barrels (80 gallons) per day.

Between 15 and 20 wells have been drilled at Ledaung, about 24 miles south of Minbyin, and some are still producing oil.

Mr. G. deP. Cotter.

30. Two areas were surveyed by Mr. Cotter —one in the Minbu district and one in the Pakokku district.

Minbu District.

In the Minbu district, sheets 111 and parts of sheets 110 and 84 L/6, Burma Survey, 1″=1 m., were geologically mapped. The Pegu beds are found in the West of sheets 111 and 84 L/6, dipping very regularly east, except in the neighbourhood of Ngahlaingdwin where they are disposed as an anticline. Mr. Cotter was able to differentiate the Pegu beds into three groups which grade insensibly into one another. The upper group consists of shallow water deposits with current-bedded sandstones, selenite and shallow water fossils including *Cyrena crawfurdi* and *C. khodaungensis*. In the middle group, current-bedding is uncommon, the rocks are harder, the clay beds more sharply differentiated from the sands, and the fossils belong to the "laminaria" zone. The lower group resembles the middle, but the sandstones are coarser and harder and the limestone bands slightly more frequent. A species of *Heterostegina* and a nummulite, most probably of oligocene age, were found at an oil seepage 3 miles N.N.W. of Ngahlaingdwin. Another seepage occurs 3½ miles W.S.W. of the same village. The Ngahlaingdwin anticline is steeper on the west than on the east; and since it sinks rapidly southwards in the area mapped, Mr. Cotter is of opinion that it would be well worth while to examine the area to the north in sheet 84 L/5 before testing near Ngahlaingdwin.

Pakokku District.

In the Pakokku district the Myaing anticline was examined and surveyed with the aid of cadastral maps on a scale of 2″= 1 m. The anticline, consisting of Pegu and Irrawaddy beds, resembles that of the Gwegyo hills. The crest is

recognisable near Chaingzauk, but southwards has been faulted away by what Mr. Cotter considers to be probably a thrust-plane on the east. Fossils of the usual Pegu types were found together with selenite and fossil-wood, the latter being fairly common in the Pegu rocks. There are many gas pools, but Mr. Cotter considers the area unpromising for oil boring on account of the contortion and faulting.

Myingyan District. Sub-Assistant Sethu Rama Rau.

31. The following sheets of the Burma Survey 1″= 1 m. were mapped geologically: parts of 109 and 112, east of the Irrawaddy, the northern half of sheet 153, and the whole of 156.

In sheet 109 the eastern boundary of the Pegu inlier of Singu was mapped for the first time on this scale, as also was the northern part of the Gwegyo anticline and the southern extremity of the Pagan fold. Cone-in-cone structure was found in many places in the northern part of the Gwegyo anticline.

In sheet 153 the rocks east of the Popa area were found to be folded into successive sharp anticlinal and synclinal folds and consisted of Pegu strata. The crests of the anticlines usually occupy low ground, and their direction is about 40° W. of N. to 40° E. of S. Sandstones predominate over shales, and some contain many nodules of carbonised wood enclosed in pyritiferous sandstone. Fossil bands are plentiful, the commonest species being *Turritella simplex* and *T. acuticarinata*. Specimens of *Batissa* including *B. khodaungensis* were also obtained.

The country surveyed in sheets 156 and 112 (E. of the river) is that around and east of Magwe. In it was discovered the Pegu inlier of Ondwe on which a short note has already been published (*Records*, Vol. XXXVIII, Pt. 2, p. 152) and which is shortly to be tested for oil.

Possible oil-field in Las Bela and Southern Mekran.

32. Mr. Vredenburg in a recent paper in the *Records* (Vol. XXXVIII, Pt. 3, p. 206), has called attention to the possibility of petroleum being found in Las Bela and the Mekran district, in rocks belonging to the Hinglaj series which correspond with the oil-bearing strata of Burma. The structure is favourable for the storage of petroleum in large quantities underground should it exist, and though no oil seepages occur, the presence of mud volcanoes along the crest of some of the anticlinal axes is a favourable sign.

The other minerals found in southern Baluchistan were noticed in the General Report for 1906 (*Records*, Vol. XXXVIII, Pt. 1, p. 50), and are described in greater detail in Mr. Vredenburg's paper cited above.

Road-metal and Building Stone.

Road-metal for Rangoon.

33. Reference has been made in previous General Reports (*Records*, Vol. XXXIII, Pt. 2, p. 85, Vol. XXXV, Pt. 1, p. 30) to the question of an adequate supply of road-metal for Rangoon, the cost of importing such material from Bombay and Mauritius having become prohibitive in view of the rapid extension of the roads of the city and its surroundings and the great increase of traffic within the last few years. Formerly the Bombay basalt was brought in by ships in ballast and was collected at little cost to the Municipality, but the opening of direct steamship communication with foreign countries has cut off this source of supply. At the request of the Chief Engineer to the Government of Burma, Mr. P. N. Datta was deputed to examine the crystalline rocks of the Thatón District, Lower Burma, rendered accessible by the opening of the Pegu-Moulmein Railway, and his report, submitted in May 1909, shows that there is a practically inexhaustible supply of gneiss and granite to be obtained within easy reach of the line. These rocks, though perhaps not quite so durable as the Bombay basalt, will no doubt serve the purpose required at far less cost than the imported material.

Taungu stone quarries.

34. In the General Report for 1908 (*Records*, Vol. XXXVIII, Pt. 1, p. 46) reference is made to a visit by Mr. G. deP. Cotter to the stone quarries of Taungu, Lower Burma, in order to advise the Public Works Department, Burma, regarding the location of a Government quarry for the supply of building stone. Mr. Cotter's report, submitted in April 1909, shows that building stone of two qualities may be obtained in large quantities from these quarries—

(1) A yellow calcareous sandstone occurring in a bed from 200 to 300 feet thick, and extending for a mile along the strike. This is somewhat soft when freshly cut, but hardens on exposure to the air.

(2) Purple, sometimes pink, sandstone of medium grain, very slightly calcareous and considerably harder than the yellow sandstone. It occurs in layers averaging about 6 inches in thickness, but slabs of one foot thick might be obtained. Other localities in the neighbourhood were visited, but the stone was found to be of inferior quality.

Salt.

35. The relics of a once flourishing salt manufacturing industry in the Myingyan District, now moribund on account of the competition of imported salt, are described by Sub-Assistant Sethu Rama Rau. The inhabitants of one village, Sagyin, even now subsist chiefly on this industry, and a few others are still engaged in it. The salt is derived from springs and causes a saline efflorescence on the surrounding soil. After saturation as far as possible by repeated moistening with the water flowing from the springs and drying, the soil is lixiviated either in large conical wicker baskets or in rows of earthen pots, and the brine evaporated over a slow fire.

Salt manufacture. Myingyan District, Burma.

Water.

36. Many applications have been received from Local Governments and private individuals during the year for advice regarding the search for artesian water in various parts of India. Where these enquiries are concerned with the great expanses of alluvium that cover the valleys of the Indus, Ganges and Brahmaputra the advice of a Geologist is of little value, as the alluvial strata lie horizontally and information regarding the distribution of sub-soil water can be obtained only by actual experiment, that is to say by well sinking or boring. In hilly tracts on the other hand the possibility of obtaining artesian water depends entirely on local conditions and it is not often possible to ascertain these from a small scale geological map without personal inspection of the ground. The following is a summary of the work that has been done during the year.

37. A boring was put down close to the Political Agent's house at Mastung to supply drinking water, and was carried to a depth of 510 feet without meeting with water under sufficient pressure to bring it to the surface. The rocks passed through, judging from the samples submitted, were Siwalik clays, with a bed of loam at 410 feet, from which water rose to between 13 and 17 feet below ground level. This water was found to be slightly brackish, but it is not clear whether the brackishness was not caused by a leak in the tube at a higher level.

Baluchistan : Mastung.

38. A boring put down to a depth of 410 feet near Said Hamid railway station (Kulozai) was not successful. It was proposed to make another attempt near Gulis-

Kulozai.

tan, 8 miles further to the south, where the conditions are similar to those at Quetta, and there are some "karezes." A supply sufficient for drinking purposes might be obtained here.

Bengal: Borings for sub-soil water.

39. Considerable activity has been shown by the Agricultural Department in Bengal in sinking borings in search of sub-soil water, in accordance with the recommendations of the Irrigation Commission. From a note supplied to this Department, by Mr. W. R. Gourlay, Director of Agriculture, it appears that operations have been carried on in nine districts, both north and south of the Ganges, and that several of the District Boards have purchased sets of tools. The wells sunk are said to have been more successful in the districts to the south of the Ganges than to the north, as the former must be sunk to a greater depth before reaching a water-bearing stratum, and, therefore, the water rushes in with greater force. On the north side the sands lie at a shallower depth, and it will probably be found advisable to sink ordinary percolation wells in this area.

Proposed deep boring at Sitamarhi.

40. In April 1909 the District Engineer in Muzaffarpur, and more recently the Secretary to the Government of Bengal, Irrigation Department, requested our advice regarding the putting down of a deep boring at Sitamarhi, in order to ascertain whether water under pressure does not exist in the coarse gravel beds that presumably lie at the base of the Gangetic alluvium. In view, however, of the distance of Sitamarhi from the northern edge of the plains, whence the water would be derived; the slight elevation above the plains of the beds into which the water percolates from the hills; and the poor results obtained from the Lucknow boring, 1,336 feet deep, in 1889, I was compelled to reply that I did not think the prospects sufficiently good to warrant the expenditure of a large sum of money on a deep boring. I think that the salvation of this and neighbouring districts will consist in the deepening of existing wells, or the sinking of borings through them, in order to reach deeper water-bearing strata in the alluvium, which may keep them supplied in times of drought.

Raniganj.

41. Messrs. Balmer, Lawrie & Co. having reported that they experienced increasing difficulties in obtaining an adequate supply of water for their Paper Mills at Raniganj from the Damuda river owing to changes in its course, and that they contemplated boring for artesian water, Mr. H. Walker was

deputed to examine and report on the possibilities of the project. He found that there was no prospect whatever of obtaining an artesian supply in the vicinity, and recommended the sinking of a number of bore-holes in the alluvium bordering the river, by which means a sufficient supply may be obtainable from a band of gravel underlying a bed of clay in the alluvium, which appears to have a considerable extension horizontally.

Bombay: Borings in Gujarat.

42. After many delays, due to the difficulty of finding a suitable site, the experimental boring in Gujarat with the Calyx drill, lent by the Geological Survey Department, was at length started in the autumn of 1909, the site finally selected being near Sanand railway station, on the Ahmedabad-Wadhwan branch of the Bombay, Baroda and Central India Railway. A report on this boring has been furnished by the Engineer-in-charge, from which it appears that water was struck at a depth of about 300 feet from the surface, but not under artesian pressure. Pumping tests have proved that a discharge of about 5,000 gallons an hour is available, but the water is of inferior quality, and is not potable. In fact it is evident from the boring records that the water comes from a bed of sand in the alluvium, and is ordinary sub-soil water. It still remains to be proved, therefore, whether water under pressure can be obtained beneath the plains of Gujarat, but in places like Sanand the alluvium is probably too thick to be pierced by a boring of reasonable depth.

It is unfortunate that the site originally selected under the advice of this Department, to the north-east of Wadhwan, was found to be impracticable. Not only is the alluvium there probably much less deep than at Sanand, but there was a prospect of reaching the Tertiary strata which may underlie the alluvium, and which might have given a fair supply of artesian water.

Burma: Artesian water at Pegu.

43. At the request of the Local Government, Mr. P. N. Datta visited the town of Pegu for the purpose of advising the Chief Engineer regarding the possibility of obtaining a supply of drinking water from artesian wells. Two sources had already been tapped by tube wells of 120 and 305 feet deep, respectively, at the Ice Factory in the town, and the existence of a water-bearing stratum at a depth of 580 feet had also been proved. Mr. Datta was of opinion, however, that the supply from the higher beds would not be sufficient for the town, as a considerable portion of it is taken by the Ice Factory, but if the water-bearing strata are continuous it should be possible to obtain a large supply from them,

if several wells are sunk at such distances apart that they do not interfere with one another.

Central India: Trial boring at Shamgarh.

44. A trial boring for water at Shamgarh station on the Nagda-Muttra Railway proved unsuccessful, as the whole of the boring was in Deccan trap. It was thought that the trap-flow might be of small thickness, and that water might be found beneath it, but after boring to a depth of 217 feet the experiment was abandoned.

Eastern Bengal and Assam: Chittagong.

45. On his way to Upper Assam in November 1909, Mr. Hayden visited the tube wells at Chittagong which have been sunk by Messrs. Kilburn & Co. in accordance with the advice given by him after an inspection of the locality in 1906. In the first instance an experimental bore of 3⅜ inches in diameter was put down to a depth of 700 feet. Three water-bearing bands were met with, one of 10 feet thick at 165 feet, the second of 40 feet thick at 215 feet, and the third of 92 feet thick at 335 feet from the surface, respectively. Below this no more water-bearing strata were found. The water from the band at 335 feet, that from the upper layers having been blocked off, rose to 8 feet below the ground level, and pumping tests showed that a constant yield of about 1,100 gallons an hour, capable of being largely increased with a more powerful pump, could be obtained from this band. It was then decided to sink two other tube wells of 6 inches diameter each, near the original boring, and these have now been drilled, but only one has been fitted with machinery for testing the yield. This is about 9,000 gallons per hour, and it is estimated that the two six-inch wells will give an ample supply for the town, the requirements being about 300,000 gallons a day. The water is derived from Tertiary sandstones which have their outcrop in a ridge of low hills lying to the south-west of the town and is therefore under artesian conditions, though the effective head, owing to the low elevation of the outcrop, is not sufficient to force the water above the orifice of the bore hole.

Jorhat.

46. Since the year 1906, the Public Works Department has been engaged in putting down a boring for artesian water at Jorhat in Upper Assam. Last year this boring reached a depth of 365 feet, and samples of the strata passed through were sent to this Department for determination. From these it appears that the boring has not yet reached the base of the alluvium, and no indications of water under pressure have been met with.

47. A boring was put down in the grounds of the Khalsa College at Amritsar in the hope of striking artesian water, but at a depth of 215 feet, operations were suspended through lack of funds. The boring records show that at this depth the alluvium had not been pierced, but the Principal of the College states that at 60 feet a practically unlimited supply of water was met with, though not under pressure. The distance of Amritsar from the edge of the plains, about 50 miles, is probably too great to hold out much prospect of reaching the base of the alluvium at a reasonable depth from the surface.

Punjab: Amritsar.

48. The Government of the United Provinces has asked our advice regarding the sinking of artesian wells in the portion of Bundelkhand not occupied by Native States; but the greater part of the area specified consists either of metamorphic rocks or alluvium, while the narrow strips of Vindhyan rocks in the Lalitpur district are so disposed that there is no prospect of obtaining artesian water from them. It would be useless, therefore, to spend money on deep borings in this area.

United Provinces: Bundelkhand.

49. The Department of Land Records and Agriculture in the same provinces has shown great activity in putting down shallow bore-holes as a preliminary to sinking percolation wells, with a very gratifying measure of success. During the official year ending in 1909, over 1,000 of these borings were made, and in certain cases samples of the beds passed through have been sent to this Department for determination. As a general rule, the borings are not over 100 feet in depth, being usually stopped at this point if water is not met with, and none of them appear to have been carried far enough to determine the thickness of the alluvium out in the plains.

Borings for sub-soil water.

GEOLOGICAL SURVEYS.

Aden.

50. An interesting paper has been contributed to the *Records*, Vol. XXXVIII, Part 4, by Captain R. E. Lloyd, I.M.S., Surgeon Naturalist, Marine Survey of India, giving the geological results of a tour made by him in 1906 through the little known country to the north of Aden. Mr. F. R. Mallet had made a short expedition through this country in 1870, but was able to reach only the foot hills and determine the presence of fossiliferous limestones there.

Capt. R. E. Lloyd, I.M.S.

Captain Lloyd was able to penetrate 10 miles into the hills, and ascended to Dala, which lies among hills of six or seven thousand feet in altitude. The rocks met with on the road were a sedimentary series of limestones and sandstones and a more recent igneous series, covering a much wider area than the sedimentary rocks, and separated into :—

(1) Massive lavas :—these occur above the others and form plateaus and pinnacles which give a characteristic appearance to the landscape;

(2) Horizontally bedded lavas, consisting of alternating layers of compact black lava and amygdaloidal lava;

(3) Beds of volcanic ashes of brightly variegated colours, dipping at pronounced angles, usually less than 30°.

It is not quite certain from Captain Lloyd's description, whether the dip of these beds is original and due to the presence of a centre of volcanic activity in this neigbourhood, or whether it is due to subsequent tectonic disturbance. As Mr. Vredenburg points out, the sedimentary rocks are similarly inclined, and he thinks therefore that there may have been a long interval between the deposition of the ash beds and the eruption of the undisturbed massive lava, which may be of quaternary age, like the Aden volcano.

The sedimentary rocks are older than the igneous series, but the uppermost beds show traces, in the presence of beds of volcanic fragments, pebbles of lava, etc., of the setting in of volcanic conditions. The limestones are highly fossiliferous and have been shown by Mr. Tipper to be of Upper Jurassic age (*see* above, p. 85).

The petrology of the rocks collected by Captain Lloyd has been worked out by Mr. Vredenburg (*see* above p. 85), and the results of his investigations, with those of Mr. Tipper on the palæontology are published in separate papers in the same part of the *Records*.

Burma.

51. Part of the survey work in Burma is described above under the heading of *Petroleum*, wherever the areas dealt with have been mapped during the course of the search for new oil-fields. A considerable amount of mapping has also been carried out in other areas and a distinct advance made in the correlation and description of the Tertiary deposits.

52. In addition to the special enquiry into the suitability of the crystalline rocks of the Thatôn district for road metal, Mr. P. N. Datta made a geological survey of the western parts of the district.

Thaton District, Lower Burma: Mr. P. N. Datta.

The rocks met with were:—

Alluvium.

Laterite.

Sedimentary rocks:—Sandstones and shales, more or less metamorphosed in places.

Crystalline rocks:—(i) Volcanic (probably rhyolitic); (ii) Granite, and (iii) Gneiss with mica and quartz schists.

A good section of the sedimentary rocks was found in the new cuttings for the railway at Martaban Station. Here some of the shales are highly carbonaceous and contain plant remains, too fragmentary to admit of identification, and bivalves, with casts of what appear to be *Orbiculoidea* and the wings of insects. None of these is sufficiently well preserved or characteristic to enable the exact age of the beds to be determined, but there is no doubt that they belong to the 'Moulmein Group' of Dr. T. Oldham, and are probably of carboniferous age.

Section at Martaban.

The crystalline rocks are of ordinary types and call for no special remark, but Mr. Datta thinks that the granites and rhyolites, which were included by Mr. Theobald with the gneisses in his 'Martaban Group,' are really intrusive, and may be of post-carboniferous age.

53. On his return from Kyaukphyu in February, Mr. Pascoe made an attempt to map the Pegu beds of Yenangyaung, but found that the conditions were such that no definite boundary lines could be drawn. At Yenangyaung the Pegu beds are of a shallow water type and extremely variable in thickness, so much so that it was found impossible to recognise the division made by Dr. Noetling, who separated the Pegu series into a lower or Prome stage, and an upper, or Yenangyaung stage. The question is of some importance, since if horizons of definite composition could be recognized in this enormously thick series of beds, it would render the mapping of the anticlines or domes beneath which petroleum is likely to be found, and the determination of faults, a much more simple matter than it is at present. Mr. Pascoe suggests that, instead of attempting to map the various groups of beds, which are constantly changing in composition, a better method would be to lay down each outcrop observed accurately on a large scale

Pegu beds, Yenangyaung.

map, and deduce the structure of the rocks from the series of strikes thus obtained. But the chief objection to this course would be the necessity of constructing a special map (on a scale of at least 8 inches to the mile) for each locality visited.

The volcano of Popa : Mr. E. H. Pascoe.

54. As a result of surveys carried on during the final months of two field seasons around the ancient volcano of Popa in the Myingyan district, more than half the area has been mapped. The northern part of the crater-wall is missing, and the rest is formed of breccia or agglomerate. There is a conspicuous parasitic cone on the west known as Taungkalat. A large part of the mountain is made of Irrawaddy sandstone, and a few small inliers of beds resembling the Pegu are observable in a few places. The oldest bed is an ashy tuff interbedded in the Irrawaddy sandstone. The lavas are mostly andesites, both hornblende and augite varieties being represented. An account of the volcano will be published as soon as the petrographical details of the rocks collected have been worked out.

Country south of Mt. Popa : Mr. K. A. K. Hallowes.

55. Mr. Hallowes was engaged in examining the country immediately south of Mt. Popa. The Kyaukpadaung Hills were found to be composed of altered silicified tuffs, with some interbedded altered rhyolites, associated with pumice and volcanic agglomerate. East of Leya altered tuff and rhyolite occur interstratified with Irrawaddy sandstones. The small hill of Taungnauk between Kyaukpadaung and Popa consists of altered silicified tuffs with some interbedded rhyolitic lava flows. The junction between the Pegu and Irrawaddy series south of Popa was found to be covered by an extensive sheet of hornblende-andesite. The crater of Mt. Popa itself, according to Mr. Hallowes, lies upon a fault. The hill known as Taungni was found to be composed of altered lavas and white flour-like tuffs, some of which have been highly silicified; it is probably an old tuff cone. Mr. Hallowes reports the discovery of tuffs interbedded in Pegu sandstones near Leya and elsewhere, indicating that volcanic activity in this area existed in pre-Pliocene times. East of the Kyaukpon hills is a large tract of Pegu rocks bent into more or less parallel anticlines striking about 30° W. of N. In these *Turritella acuticarinata* and *T. simplex* occur in great profusion. There are no good prospects of obtaining oil here.

Western Prome : Mr. M. Stuart.

56. The localities examined and mapped by Mr. Stuart during the season 1908-1909, were North-West Prome, South-West Thayetmyo, and Yenangyaung.

The results of these surveys have already appeared in Vol. XXXVIII, Pts. 2 and 4, of the *Records*.

The mapping made it evident that Theobald's classification of the Pegu system was the most suitable one, *viz.*:—

4. Kama clays.
3. Upper Prome series.
2. Lower Prome series.
1. Sitsayan shales.

and that Noetling's later suggestion to incorporate the Kama clays and the Upper Prome series into one series, which he called the Yenangyaung stage, and the Lower Prome series and Sitsayan shales into another series, which he called the Prome stage, could not be entertained.

It also became evident that the old method of classifying the fresh-water deposits as the Irrawaddy system and the underlying marine beds as the Pegu system could no longer be adopted, but that the division between the two systems must be made at the horizon of the unconformity which exists some distance below the base of the fresh-water beds. This unconformity is scarcely visible in any individual section, but on mapping the junction of the two systems is seen to be of considerable importance and extent. This brings a series of marine beds into the base of the Irrawaddy system, which series is represented in the district mapped by the beds on which the town of Prome is situated. This series of marine beds is described by Theobald as overlying the Kama clays, but is incorporated by him with the Pegu system. The Kama clays are therefore the highest beds of the Pegu system seen in the district.

It was also ascertained that there is a distinct unconformity between the base of the Pegu system (Sitsayan shales) and the Bassein system. The age of the topmost beds of the Bassein system which are seen in the district are of Eocene age.

Classification of Tertiary Strata.

57. The succession in the district is therefore:—

Irrawaddy system		{ Fresh-water series. { Marine series.
	Unconformity.	
	3. Kama clays.	
Pegu system	2. Prome beds .	{ Upper series. { Lower series.
	1. Sitsayan shales.	
	Unconformity.	
Bassein system.		

58. Another point which was suggested by the detailed mapping of the district was that all the oil seepages in the district from the Pegu system come from the Kama clays, and that none occur in the system below this horizon. This observation is in direct conflict with Noetling's assertion that all the oil in the Pegu system comes from the Lower Prome series and Sitsayan shales (his Prome stage).

Oil horizon.

59. The structure of the Padaukpin and Banbyin area proved to be an anticline in marine Irrawaddy beds with the underlying Kama clays exposed in the crest of the anticline. Owing to the unconformity between the two systems there is not any definite anticlinal structure in the Kama clays, which are here several thousand feet thick. The marine Irrawaddy beds have a lower angle of dip in an easterly direction than the underlying Kama clays, and where the latter again crop out near Aukmanein, some ten miles to the west, only 1,200 feet of them are seen.

Structure.

In view of the discovery of this structure, the fossil evidence obtained from the oil-fields of Minbu, Yenangyaung, Singu, and Yenangyat was examined and was found to favour the view that in each case the structure was similar to that of the Padaukpin-Banbyin area, and that the Pegu beds exposed in the various oil-fields were an upper development of the Kama clays.

A separate investigation was carried out on the fossil fish teeth obtained and their evidence generally supported the above view.

Central India and Rajputana.

60. The first two months of the season Mr. Jones spent in putting the finishing touches to his last year's mapping in the neighbourhood of Rampura in the Indore State and in parts of Jaora. This work, which connects our present survey with the old work of Messrs. Hacket and Kishen Singh, has already been summarised in some detail in last year's General Report (*Records*, Vol. XXXVIII, Part 1, p. 62). Nothing fresh of any importance was found in the area with the exception of a few small inliers of Delhi rocks among the Deccan Trap at Dhorwara (24° 13′ ; 75° 10′) and Diknio (24° 10′ ; 75° 5′), and some ancient workings for iron (magnetite and hematite of poor quality) in the Suket shales at Pardha (24° 32′ ; 75° 13′).

Mr. H. C. Jones: Indore and Jaora.

61. The area next taken up by Mr. Jones was that of Gwalior State near Gwalior town, at those interesting localities where the Gwalior representatives of the Bijawar series are found lying unconformably above the Bundelkhand gneiss, and the Upper Vindhyans in turn unconformably above both.

Gwalior.

The whole of this area had already been mapped on the one inch scale by Messrs. Hacket and Kishen Singh; whilst the former had also given a short, but comprehensive account of its geological structure (*Records*, Vol. III, p. 33-42, with map and further notes in *Records*, Vol. X, p. 84). The aim of Mr. Jones' visit was primarily to examine some mineral occurrences which the Gwalior Durbar was anxious to have an opinion about. Incidentally, however, a re-examination of the general geological structure of the country was undertaken, and typical specimens of all the rock series were gathered and described in more petrological detail than was previously possible. Mr. Jones' report is very full and is illustrated by numerous very clear photographs and a few local sections. Much of it, however, is a repetition of observations already made by Hacket, expanded by further detail, and enlarged by more illustrative descriptions of local occurrences. The general stratigraphy of the area remains unchallenged. No better examples of the supposed corals (as recognised by Dr. Stoliczka) from the limestone bands of the Morar shales (see *Records*, Vol. III, p. 35) were obtained and Mr. Jones has been unable so far to improve upon the successional arrangement of the series of limestones, traps, felsitic rocks, shales, jasper, hornstone and clay bands belonging to the Morar series, in expansion of Hacket's section given at p. 36 (*loc. cit.*). They still appear very vaguely outlined as lying generally above the Par sandstone at uncertain positions, whilst the genetic relations of many of these remarkable petrological types have not been further enquired into (compare rocks of the same age and general composition in the Son valley; *Memoirs*, Vol. XXXI, Pt. 1, pp. 58-92). The following is a brief outline of Mr. Jones' results as obtained in his examination of sheets 365, 366, 383, 399, 400 and 401 of the Central India and Rajputana topographical survey, between latitudes 25° 45′ and 26° 15′ and longitudes 78° 0′ and 78° 45′.

62. Typical Bundelkhand gneiss with pegmatites and quartz reefs, agreeing in every way with the descriptions of Mallet (unpublished reports summarised in the *Manual*, 2nd Edn., p. 27), occupy the low ground in the south-east of the area, and Mr. Jones has given a number of particular descriptions from special localities, accompanied by microscopical

Bundelkhand gneiss and quartz reefs.

determinations. All appear to be varieties due to local concentrations, or particular mineral segregation, of one Archæan mass that cannot be further sub-divided.

Galena and Copper Ores.

63. It is in these rocks that trenches have been opened for galena at Ragonathpur (26° 4′; 78° 20′) at Bhilowa (26° 3′; 78° 20′) and kaolin quarries at Antri (26° 3′; 78° 17′). Specks of galena and some pyromorphite were found in the first, but nothing at Bhilowa. Traces of galena, malachite and azurite were also found 2½ miles west of Karhia (25° 54′; 78° 4′).

Scarcely any metallic minerals were found in the quartz reefs penetrating the gneiss. Small specks of copper pyrites, covellite and malachite are mentioned as present, but no gold. Assays of 4 of these veins were made in the Geological Survey laboratory by Mr. Blyth without any trace of gold or silver being obtained. The pure white variety of quartz from the reefs is used for the manufacture of glass at the Gwalior (Morar) works.

Trap dykes.

64. The trap dykes of the area, previously described by Mallet (*loc. cit.*) are identified by Mr. Jones as ophitic dolerites, consisting of pale brown augite, plagioclase felspar (labradorite), magnetite, and ilmenite frequently altered to leucoxene. Altered varieties occur containing saussuritised felspar, hornblende, epidote, quartz chlorite and hematite.

Bijawar Rocks and Upper Vindhyans.

65. A large number of notes on the Bijawar rocks of the area (Par sandstones and Morar group of shales) have been put together by Mr. Jones in amplification of Hacket's original description (*Records*, Vol. III, pp. 33-42). They constitute a set of isolated petrographical descriptions of specimens and sections from many localities, but as already remarked, their mutual relations and mode of origin have not as yet been further elucidated.

Interbedded traps.

66. The interbedded traps associated with the shales compose five main spreads, and have been determined as labradorite-augite-magnetite rocks.

Mr. A. M. Heron: Alwar State.

67. Mr. Heron, in his new survey of Alwar State, has contributed a very carefully coloured map and detailed report, illustrated with sections and an admirable array of photographs. The area treated of is chiefly in Alwar, with portions of Jaipur and Bharatpur States, as shown in sheets 286, 287, 288, 314, 315, 316, 339 and 340 of the Central India and Rajputana topographical survey.

General Results.

68. His results comprise a return to the original view of Hacket, (*Records*, Vol. X, Pt. 2, p. 85) as regards the rock succession, a matter which requires a few words of explanation. In the above cited reference, Hacket, after surveying the area in detail, arranged the formations as below:—

Arvalis
- Mandan group of slates, schists and quartzites;
- Ajabgarh „ of slates, quartzites, horn-stone-breccia and limestone;
- Alwar „ of quartzites, conglomerates, schists and bedded trap;
- Raialo „ of limestone and quartzites;

and the small scale-map, illustrating that published report is coloured according to this scheme. Later, however, in consequence of work in other parts of Rajputana to the west, he formally abandoned this view (*Records*, Vol. XIV, Pt. 4, p. 281) and wrote:—

"In my description of a portion of this area, the Alwar hills, in a previous paper, I placed the Ajabgarh and Mandan groups at the top of the Arvali series above the Alwar quartzites. Upon further examination of the series in the country to the west, where the sections are less broken, I found that this was not the true interpretation of the section, but that both these groups were below the quartzites, in fact, representatives of the Raialo group. I was led into this error by the high dip of the rocks and by taking inversion for the normal sequence.

I also then included the Alwar quartzites with the Arvali series, but as in the western area the quartzites are found to constantly overlap the lower rocks; as also several cases of unconformity have been noticed it is necessary to separate these two series. As the quartzites extend up to Delhi and form the ridge there, I now propose to call the quartzites and their associates in the Mandsaur hills and elsewhere the Delhi series, retaining the name of the Alwar quartzites for the lower member of the series."

A small-scale map illustrating the above paper is also coloured according to the new view; whilst, what is of even more importance, the signed fair copies of the large-scale, 1″=1 mile, maps handed in by Mr. Hacket in 1882, and stored now in the map cases of the department were also coloured according to this later view and indexed thus:—

Delhi series (=Alwar quartzites).

Arvali series with limestone, hornstone breccia, and trap (=Ajabgarh series).

It should be noticed that this change of view of Hacket was made without his re-surveying the Alwar area, and without his supporting it by detailed sections, his paper in Vol. XIV of the *Records* being the last published account that Hacket wrote.

Hornstone-breccia and thrust-plane.

69. Mr. Middlemiss, on visiting the area for a few weeks in Mr. Heron's company during the latter's survey, was particularly struck by the peculiar appearance and lie of the hornstone breccia, which both he and Mr. Heron agreed in viewing as a fault-breccia due to an *in situ* smashing and tearing asunder of the beds at various horizons near those of the Kushalgarh limestone and the Ajabgarh shales. Mr. Middlemiss, believing it to be the record of a great thrust-plane, suggested to Mr. Heron that it might possibly account for the two opposite interpretations of the sequence held by Mr. Hacket at different times. Mr. Heron, however, in his report, whilst accepting the theory of it as a nearly horizontal plane of movement, does not accept this suggestion as accounting for the sequence observed, which he simply describes in full detail on the basis of the original (but since superseded) description of Hacket as given in Vol. X of the *Records*.

Although the full petrographical descriptions of Mr. Heron are very carefully worked out, and are a distinct advance on anything hitherto attempted, it is to be hoped that further work in adjacent areas will enable Mr. Heron to clear up this question categorically.

Mr. N. D. Daru: Partabgarh and Banswara.

70. Mr. Daru broke new ground in Banswara, continuing in a north and westerly direction the survey of that State already begun by Mr. Heron during the previous field season. In preparation for this, he, in the first instance, spent a short time in the neighbouring State of Partabgarh, accompanying Mr. Heron in a study of the rock groups there displayed along the junction of the old work and the new.

Area surveyed.

71. Mr. Daru was able to map geologically a considerable area within sheets 175, 176, 208 and 209 of the Central India and Rajputana topographical survey, the last two of which (begun by Mr. Heron) he has now completed.

In carrying out this he followed the delineation scheme of his predecessors as closely as possible. The outliers of Deccan Trap, which lie flatly in the usual, absolutely unconformable way above the older rocks, were continued into the newly explored ground, where they were found to occupy the higher hills and ranges. As regards the older systems, he was able to distinguish and separate from a general ground work of presumably Archæan gneisses and other crystalline rocks, a set of presumably much younger, metamorphosed sedimentary rocks, consisting of limestones, shales, slates or phyllites, garnet-quartz-biotite schists, boulder beds and

schistose conglomerates. These were found to be all highly inclined or vertical as to their dip, either forming comparatively large spreads or narrow and frequently interrupted strips with a general N. 30° W.—S. 30° E. alignment.

Difficulties of interpretation.

72. In spite of the wide areas of these rocks exposed in certain parts of Banswara, both Mr. Heron and Mr. Daru found difficulty in interpreting the depositional order of the various sediments which composed them. Their outcrops are certainly not wanting in continuity and parallelism over considerable tracts; but the chief difficulty seems to be their obscure junctions with the Archæan ground-work, and their steep dips; which latter, even where they occasionally give rise to anticlinal and synclinal flexures, nevertheless cause the younger series to appear as a whole more like parallel packets of strata thrust on edge amongst the Archæans than like outliers resting upon the same. Mr. Daru is disposed to accept a descending order agreeing with that given in the preceding paragraph, with the exception that the limestone bands appear at varying horizons.

Equivalents of Hacket's Aravallis.

73. Notwithstanding this, Messrs. Heron and Daru's work taken together comprises a detailed descriptive account and large-scale map covering their joint area which now become of value in discussing questions of correlation. The younger metamorphic series as a whole, and certainly as regards its larger spreads, must now be regarded as identical with the great group which has been classified by Hacket as Aravallis, and mapped by him in the sheets a little way to the north of the area now dealt with. It would also seem to be likely that the interrupted bands of crystalline limestone, quartzite, limonite-quartz rock, grünerite rock, etc., which appear in very narrow outcrops among the wide area of mixed gneisses, and which were last year temporarily included with the mixed gneisses, should also be considered as long extended outcrops connected with the younger series rather than with the older Archæan complex—or as outcrops owing their narrow interrupted state to the circumstance that they are the remnants of almost obliterated troughs of compressed folds. This last explanation at all events seems to be the only one capable of accounting for the very elongated strip of the Masania conglomerate (23° 57′; 74° 34′) which continues for many miles with a very narrow outcrop as an isolated band among the gneisses.

Conglomerates and Boulder beds.

74. The conglomerate mentioned above is composed of flattened lenses of quartz held together by an argillaceous, chloritic or sericitic cement, and roughly resem-

bling augen-structure; but another much coarser conglomerate or boulder bed, which Mr. Daru now thinks distinct from the former, is of considerable interest. It occurs prominently at Loaria (23° 46′; 74° 10′) and resembles that from Kusalgarh described by Mr. Heron, having a matrix of biotite schist, and contained boulders ranging up to the size of three times a man's head. These are sub-angular in shape, and consist of granite, gneiss, syenite and fragments of quartz, of felspar and of biotite rock. This remarkable bed is in direct connection with the schists and phyllites of one of the larger spreads of the younger metamorphic series.

Suggested resemblance to the Dharwars.

75. A boulder bed of the above nature, so aggressively significant of all that can be implied by a great unconformity, is nevertheless at variance with the peculiar position of the whole series, smothered as it appears to be by the surrounding gneissic system, and also at variance with other evidence of intrusive action both of quartz veins and granite among many members of the series. We are herein reminded of the similar paradoxical relations subsisting between the Dharwars and massive gneisses of South India, a resemblance which may even not be without value as an index of age.

In view of the position suggested by Mr. Daru for the conglomerate and boulder bed among the younger metamorphic Aravallis, it is difficult to correlate it with the somewhat similar boulder bed near Udaipur to the north. The latter is said to occur doubtfully at the base of the Alwar quartzite and between it and the older schists. (C. A. Hacket, MS. Report, 1886, quoted in the *Manual*, 2nd Edn., p. 68.)

Doubtful rocks.

76. Both Mr. Heron and Mr. Daru have, in addition to the above, recorded some compact quartzites and schists which they cannot definitely assign to the younger (Aravalli) series; whilst at the same time they consider them as unlikely to belong to the still newer Delhi series of Hacket. In these cases, as in all those involving narrow strips of rock types isolated by want of exposures or by alluvium, the coincidence of strike that obtains throughout all the rock complexes below the Deccan Trap, renders the sorting of every known outcrop exceedingly difficult.

Archæan complex.

77. No attempt was made to limit by definite boundaries and colours on the map the various members of the Archæan system among themselves. In this matter Messrs. Heron and Daru have both been compelled to follow the only feasible plan of indicating by one or two signs superposed

on one uniform wash of colour such marked lithological types as massive acid and basic intrusions, wherever such could be distinguished as exercising a predominating effect in the field. Thus the mixed gneisses are left in possession of the greater part of the area coloured Archæan, with here and there patches of granite, syenite, aplite, pegmatite and basic dyke rocks. This, though a superficial method, and one giving no clue to the genetic relationships of the rock masses to one another, is nevertheless a slight advance on the work of the older survey in neighbouring parts; but it would be premature at present to attempt any closer descriptive summary of results. This rock group may undoubtedly, as a whole, be correlated with the "gneiss" of Hacket in the area of the Aravalli Range to the north.

Punjab.

Dr. G. E. Pilgrim: Upper Tertiary Fresh-water strata.

78. In continuation of his survey of the ossiferous deposits of India, Dr. G. E. Pilgrim visited that portion of the Punjab, lying between the Jhelum and the Indus, known as the Potwar, the Salt Range and the Murree Hills Sub-Assistant M. Vinayak Rao was employed in collecting from the same district under Dr. Pilgrim's direction.

As the result of his investigations, Dr. Pilgrim has been able to arrive at certain definite and important conclusions regarding the divisions of the Tertiary fresh-water strata of the Punjab, and their correlation with the Siwalik formation in other parts of India.

A full summary of these conclusions with a revised classification of the Upper Tertiaries of India will appear in the *Records*.

Kuldana series of Fatehjang.

79. In the first place Dr. Pilgrim shows that the nummulites associated with the mammalian fauna of Fatehjang, near Rawalpindi, which led Lydekker to refer these beds to the eocene (Khirthar) period are not *in situ*, and that great unconformity really exists between these beds and the Khirthars. The presence of *Anthracotherium bugtiense*, *Brachyodus africanus*, and other Upper Nari forms, clearly denotes the age of these beds, which are identified with the Kuldana series of Middlemiss, and pass upwards into the Murree sandstones. These latter beds thin out rapidly towards the south and are not represented in the Salt Range, where the Kuldana beds are followed by a series of beds correlated with the lower Siwaliks of Sind and the Bugti Hills.

Middle Siwaliks of the Potwar.

80. One of the most important discoveries made by Dr. Pilgrim is the fact that the collections made by Mr. Theobald in the Potwar, from beds supposed to be on

the same horizon as those mentioned above, really belong to a horizon some 5,000 to 8,000 feet higher in the series. This fauna, to which Dr. Pilgrim restricts the term Middle Siwalik, is quite distinct from the lower one, the most striking features being the absence of *Dinotherium* and the abundance of *Hipparion*, Giraffoids and the large antelopes. Furthermore, Dr. Pilgrim has proved the passage of these Middle Siwalik upwards into beds containing a fauna identical with that of the Siwalik hills in the typical area. These latter beds had been traced by Medlicott and Theobald in practical stratigraphic continuity through Jammu and Kangra as far as the Pabbi Hills on the east side of the Jhelum, so that it now becomes possible to correlate the Siwaliks of the Siwalik Hills with the Upper Tertiaries of Western India.

Siwalik Hills.

81. Dr. Pilgrim also paid a visit to the Siwalik Hills in order to investigate a supposed bone deposit. This turned out to be merely a deposit of calcareous tufa; but he was able to re-visit several of the old localities, which appear to have been worked out by former collectors, and discovered the important fact that most if not all of these localities are near the top of the series. The whole series of beds form a perfectly conformable sequence, and the occurrence of *Dinotherium* and species identical with those of the lower Siwaliks of the Salt Range shows that lower horizons are also represented. This is the so-called Nahan stage. With the exception of these lowest beds, the rest of the series, including both Mr. Middlemiss' 'Siwalik conglomerate' and 'sand-rock' stages, corresponds both in thickness and lithological character with the Upper Siwaliks of the Pabbi Hills. The conclusion is therefore drawn that the middle Siwalik stage in the Siwalik Hills was characterised by a remarkably slow deposition, only a few hundred feet representing the 6,000 feet or so of the fossiliferous Middle Siwaliks of the Salt Range.

No reason whatever has been seen to doubt the propriety of separating the Dagshai and Kasauli series from the Nahans, or the identity of the two former with the Murree series of the Punjab.

Kashmir.

Mr. C. S. Middlemiss: District S. E. of Srinagar.

82. During the summer of 1909, Mr. Middlemiss re-visited Kashmir, and added considerably to the discoveries made the previous year, which have been described in Vol. XXXVII, Pt. 4, of the *Records* and in the General Report for the year, Vol. XXXVIII, Pt. 1, p. 69. A

full account of these later observations will appear in the current volume of the *Records*.

The area examined is a compact one about 36 miles long by 16 miles broad, lying to the south-east of Srinagar, embracing the area in the Vihi district examined in detail last year and sections along the Patarkul, Traal, Lidar, Arpat and Naubug Valleys, which, with a north-east—south-west trend, join the Jhelum Valley above Srinagar.

In his progress through this area, Mr. Middlemiss soon found that the old interpretation of the geological series as formulated by Lydekker (*Memoirs*, Vol. XXII) needed much revision as a sequel to the more recent detailed surveys, which since Lydekker's time have been made of the Tibetan watershed of Garhwal and Kumaon, and in Spiti. A new map was therefore produced of this very typical area, and a re-grouping of the fossiliferous marine sedimentary series from Silurian to Upper Trias was instituted.

83. A large and characteristic collection of fossils was made from many of the horizons as given in the table of formations below (arranged in descending order) :—

Geological sequence.	
(12) U. Trias	(not differentiated into sub-zones).
(11) Muschelkalk	*Ptychites* horizon. *Gymnites* do. Nodular limestone.
(10) L. Trias	*Meekoceras* horizon. *Ophiceras* do.
(9) Zewan or Permo-Carboniferous	*Spirifer Rajah* and *Marginifera* beds. *Protoretepora* limestone and shales.
(8) L. Gondwanas	*Glossopteris* horizon (Karharbari ?) *Gangamopteris* do. (Talchir ?)
(7) Volcanic flows.	
(6) Agglomeratic slate series.	
(5) M. Carboniferous	(?) *Fenestella* series.
(4) L. Carboniferous	*Syringothyris* limestone series.
(3) Muth quartzite.	
(2) U. Silurian.	*Orthis* shales.
(1) L. Silurian and Cambrian ?	(traces of fossils only).

Of these, the horizons of the Upper Silurian and Muschelkalk, for the first time during this visit, were identified by beds containing abundant

faunas and arranged in regular sequence with the other formations round an elongated anticlinal axis which pitches to the north-west in the neighbourhood of the Lidar Valley.

Age of the Panjal Traps.

84 Incidentally it will be observed that the removal of the so-called Panjal traps and conglomerates of Lydekker (Nos. 7 and 6 of the table) from a low position among the (?) Silurians of that author to a much higher level, immediately below the Permo-carboniferous and Lower Gondwanas, has been found to be necessary, as was tentatively announced in the account of the previous season's work on the Lidar Valley sequence (*op. cit.*, Vol. XXXVII, p. 322).

REPORT ON GEODESY

BY

COLONEL S. G. BURRARD, R.E., F.R.S.

PRINCIPAL TRIANGULATION.

Operations were carried on in the following localities :—

(1) Northern Baluchistan.
(2) Kashmir.
(3) Upper Burma (Bhamo and Myitkina districts).

In Northern Baluchistan and Kashmir the work was a continuation of that of 1908-09, while in Upper Burma an entirely new series, the "Upper Irrawaddy," was commenced.

(1) Northern Baluchistan.

The Northern Baluchistan series emanates from the base Zawa-Zibra of the Kalat Longitudinal Series; it trends in a northerly direction as far as the Northern boundary of Baluchistan, then turning east runs through Northern Baluchistan and closes on the Great Indus Series on the side Tounsa-Langawala, just north of Dera Ghazi Khan. Two figures of the series, both tetragons, were completed in 1908, and a pentagon had been commenced.

Mr. Tresham commenced work early in September, and, after completing the pentagon, carried the work eastwards by means of a tetragon and quadrilateral as far as meridian 68° 30′. Closing work here at the end of December he transferred his base of operations to Tounsa, and commenced to work eastward from the base Tounsa-Langawala. By means of four quadrilaterals he closed on the western portion of his work at the end of April, thus completing the series.

A two-microscope 12″ micrometer theodolite was used for the observations throughout the season's work.

The total length of triangulation executed by Mr. Tresham amounts to 230 miles covering an area of 6,000 square miles. The 24 completed triangles have an average triangular error of 0″·303.

Astronomical azimuths were observed at Gundak, Saleghar and Tounsa. The difference between the observed and geodetic azimuths at the first station is + 0″·06, at the second + 1″·08, and at the third + 11″·65.

The completion of this series closes the circuit, which starting from the base Gandpahar-Kharko of the Great Indus series includes 130 miles of the Kalat Longitudinal Series, the whole length, 340 miles of the North Baluchistan Series, and 340 miles of the Great Indus Series.

The closing errors on the side Tounsa-Langawala are as follows :—

	Value from Great Indus Series.	Value from North Baluchistan Series.	Discrepancy.
Side Tounsa-Langawala .	62,321·8 feet.	62,323·0 feet.	1·2 feet.
	° ′ ″	° ′ ″	″
Latitude of Tounsa . .	30 41 51·59	30 41 51·63	0·04
„ Langawala . .	30 51 26·93	30 51 26·98	0·05
Longitude of Tounsa . .	70 41 27·31	70 41 27·55	0·24
„ Langawala . .	70 45 45·07	70 45 45·32	0·25
Azimuth at Tounsa of Langawala	201 07 42·87	201 07 45·89	3·02
Height of Tounsa . . .	593 feet.	580·5 feet.	12·5 feet.
„ Langawala . . .	500 „	484 „	16·0 „

The large error in height is probably due to the very long rays employed on the Kalat and North Baluchistan Series. Heights obtained from short rays are more reliable than those obtained from long rays.

(2) Kashmir.

It was mentioned in last year's report, that a new principal triangulation series had been commenced in Kashmir, emanating from the base Nerh-Khagriana of the North-West Himalaya Series. It was subsequently found, that it was impossible to build up any figure but that of a simple triangle on this base. As this is an unsatisfactory way of commencing a new series, connection was made with a second side of the North-West Himalaya Series, and the first figure of the series becomes a pentagon, of which two of the triangles are common to both series,

Owing to the high altitudes of the stations and the short period of the year available for observations, progress has necessarily been somewhat slow.

Mr. J. de-Gräaff Hunter, who has been the observer throughout both seasons of work, has extended the series north to a distance 90 miles from its base, covering an area of 1,600 square miles. The seven computed triangles have an average triangular error 0″·591.

During 1909 the instrument used for the observations was No. IV two-microscope 12″ micrometer theodolite; this has always been an unsatisfactory instrument, and has now been returned to the makers for improvement. In 1910 it was replaced by No. V 12″ micrometer theodolite; this theodolite has been provided with 3 microscopes in place of the two carried by the other instruments of this class, made by Messrs. Troughton & Simms for the Survey of India.

Mr. Hunter's value of the station Ismail-di-Dori which is common to the present Series and to Montgomerie's old work, differs in both latitude and longitude by 0″·03 from the values obtained by Montgomerie in 1856. The azimuth at Ismail-di-Dori of Manganawa differs from Montgomerie's by 1″·4.

The height of Choti-wala, the last station visited before closing work, is over 16,000 feet in height. It was with the greatest difficulty that the instrument could be got to the top of the hill; for 600 feet it had to be hauled up the steep slopes by men from above.

An astronomical azimuth was observed at Gangachoti. The difference between the observed and geodetic azimuths is—13″·72.

Mr. Hunter has intersected numerous snow peaks; like other experienced observers, he has found it impossible to identify peaks observed from different places; he hopes, however, to fix a large number by combining his computations with graphic methods.

Mr. Hunter, in addition to his triangulation equipment, took with him during the present season two mercurial barometers, two aneroid barometers and two hypsometers for the purpose of comparing their relative values as height measurers. The result show that at heights up to 13,000 feet the mercurial barometers gave sensibly the same readings, but the values of height deduced by Baily's formula were lower by about 200 feet than the triangulated values. The two aneroids were entirely unreliable even as regards relative heights. The hypsometers computed by the formula in the Auxiliary Tables invariably gave too high values, the excess increasing with the height. At 16,000 feet their error amounted to 600 feet.

The table attached shows the results of Mr. Hunter's observations.

Table of Meteorological Observations.

Stations.	Triangulated Height.	Mercury Barometers reduced to 62° F.						Aneroid Barometers.						Barometric Height.	Boiling Point.			Radio-meter.		Temperature Range.			Remarks.
		Hicks 577.	No. of readings.	Range.	Cray 58.	No. of readings.	Range.	Hicks 5428.	No. of readings.	Range.	Hicks 5502.	No. of readings.	Range.		Temperature.	Air Temperature.	Calculated Height.	Temperature.	Air Temperature.	Max.	Min.	No. of readings.	
	Feet.	"		"	"		"	"		"	"		"		°	°	Feet.			°	°		
Nerh . .	6076	24·06	3	·07	24·00	3	·01	23·87	3	·08	23·75	3	·09	...	201·05	46·9	6119	Not	taken	55	43		
Kandi .	4375	25·14	2	00	24·96	2	·09	25 45	2	·04	25·56	2	·04	...	Not ta	ken.	Not	taken		87	64		
Gangachoti	9990·7	20·89	16	·16	20·83	16	·12	20·46	4	·03	20·77	15	·33	...	194·22	57·7	10339	133·0°	55·5°	62·5	34·0		
Kakwa-ka-Pahar.	12985·5	18·69	3	·05	18·69	3	·01	17·92	3	·05	19·00	3	·19	* 12670	189·11	57·0	13510	Not owing mist.	taken to	58·2	38·2		
Chotiwala .	16120 app.	16·59	6	·21	Brok en		...	15·60	6	·28	16·88	6	·55	* 15910	183·75	49·5	16747	134°	62·5°	65·5	24·0		

N.B.—(1) Heights marked thus * are deduced from these and simultaneous observations taken at Baramulla.

(2) Radiometer—only maximum readings obtained given.

(3) Range of Temperature—only maximum and minimum readings obtained given.

Mr. Hunter's advance parties have built stations as far north as Gilgit. Beyond the Nanga Parbat range the strength of the monsoon decreases considerably, and it has been possible for the builders to continue work, with only occasional interruptions from rain, throughout the period of the monsoon.

Simultaneously with the work of the principal series the work of inspecting and repairing the stations of Montgomerie's series has been carried out. In 1909 the stations south of Srinagar were repaired; this year those between Srinagar and Skardu have been taken in hand.

Mr. Abdul Hai, who has carried out this work this year, is now proceeding up the Indus Valley to visit and repair stations, from which it is hoped that the high peak of Teram Kangri, discovered by Dr. Longstaff, will be visible.

Next year it is proposed to send a detachment to observe Teram Kangri from these stations, or if necessary to extend the triangulation, so as to obtain a base from which it can be observed.

(3) Upper Irrawaddy Series.

For topographical reasons it was decided to stop work on the Great Salween Series for a season, and to initiate a new Series in Upper Burma through the upper Irrawaddy basin.

This Series emanates from the side Tangte-Lakar Bum of the Great Salween Series; it will follow the eastern and northern frontiers of Upper Burma.

Lieutenant Cardew commenced work at the beginning of December and carried the Series, by means of three quadrilaterals, 112 miles in a northerly direction, when further work became impossible owing to the dense haze. His eight completed triangles have an average triangular error 0″·381 and the triangulation covers an area of 2,900 miles.

An astronomical azimuth was observed at Kumtung Bum, the value of this differs from the geodetic value by 6″·68.

The observations were taken throughout by a two-microscope 12″ micrometer theodolite.

SECONDARY TRIANGULATION.

Up to the year 1909 all triangulation work executed by the Trigonometrical Branch has, with a few exceptions, been principal work, and the gaps between principal series have been filled in by Topographical Parties with a network of tertiary work. This latter though sufficing in accuracy

left few permanent marks on which a future survey could be based. Experience in other countries has shown that periodic re-surveys are necessary, and that these re-surveys are made on ever increasing scales. It was therefore decided that the trigonometrical triangulation party should initiate good secondary triangulation with the primary object of fixing permanent stations for future use.

In order, however, that this work might be utilised for current surveys the two series selected have been carried out in localities which are actually under topographical survey.

The Mawkmai Series.

This series is based on the side Letpataung-Suletaung of the Mandalay Meridional principal series; it runs eastward to meridian 98°, then follows the Burma frontier, bends north on meridian 99°, and closes on the Monghsat Secondary Series.

The stations were built up to meridian 98° in the season 1908-09. During last season Mr. Collins with two other provincial officers of the Survey of India was employed in completing the building of the stations and taking the observations.

Owing to the bad weather experienced they were unable to complete the series, but in order to render their completed work available for topographical purposes the eastern portion of the series was closed provisionally on the Monghsat Series. There remains for work during the coming season a gap of some 20 miles in the middle of the series and an extension of the series to a more easterly base of the Monghsat Series. The length of the series when completed will be 220 miles covering an area of 2,400 square miles. The average triangular error of the 25 completed triangles is 1·99″. Except at the base stations all signals were non-luminous consisting of a pole stayed by means of ropes. The instruments used were two microscope 8″ micrometer theodolites.

The Khasi Jaintia Hills Series.

This series is based on the side Landou Modo-Mautherichan of the eastern frontier series. Mr. Smith carried the triangulation westward through the Khasi Hills up to the meridian 91°, the stations having been built the preceding field season.

Owing to dense haze it was found impossible to observe to non-luminous signals, and helios had to be employed throughout the observations. The length of the completed portion of the series amounts to 41 miles covering an area of 400 square miles. The average triangular error

of the ten completed triangles is 3·17″. Mr. Smith used a two-microscope 8″ micrometer theodolite.

The stations of the eastern frontier series on which the work is based are known to have been displaced by the severe earthquake of 1897; it has therefore been decided to continue the series westward through the Garo Hills during the coming season to close on Brahmaputra Meridional Series: the work will then be re-computed from the terminal side as the base.

While Mr. Smith was carrying out his triangulation, Mr. Wyatt completed the building of stations for the extension of the series eastward up to meridian 93°.

ASTRONOMICAL LATITUDES.

During the past field season astronomical latitudes were observed at 11 stations in the plains of Oudh, along a line running north from the Ganges, (south of Rae Bareli) to Bahraich and then east to Uska Bazar, north of Gorakhpur. The positions of the stations and the values of the deflection of the plumb-line are given in the table below :—

Table.

Name of station.	Latitude.	Longitude.	Height above mean sea-level.	Deflection of the plumb-line (A—G).
	° ′	° ′	Feet.	″
Sora T. S. . . .	26 17	81 12	400	+ 7·56
Pariaon „ . . .	25 50	81 22	346	+ 6·33
Parewa „ . . .	26 38	81 12	380	+ 7·44
Utiamao „ . . .	27 0	81 12	386	+ 4·54
Imlia „ . . .	27 19	81 8	428	— 1·07
Masi „ . . .	27 38	81 23	406	—10·38
Dadaura „ . . .	27 43	81 43	420	—14·82
Manichauk „ . . .	27 37	82 5	360	—19·23
Basadela „ . . .	27 24	82 17	366	—12·53
Pathardi „ . . .	27 26	82 45	320	—18·66
Ghaus „ . . .	27 21	83 6	296	—16·74

A positive value in the last column denotes, that the plumb-line is deflected towards the south.

The values are in accordance with those previously found south of the Himalaya. The last 5 stations are all within sight of the Himalayas, the nearest, Manichauk, being about 18 miles distant.

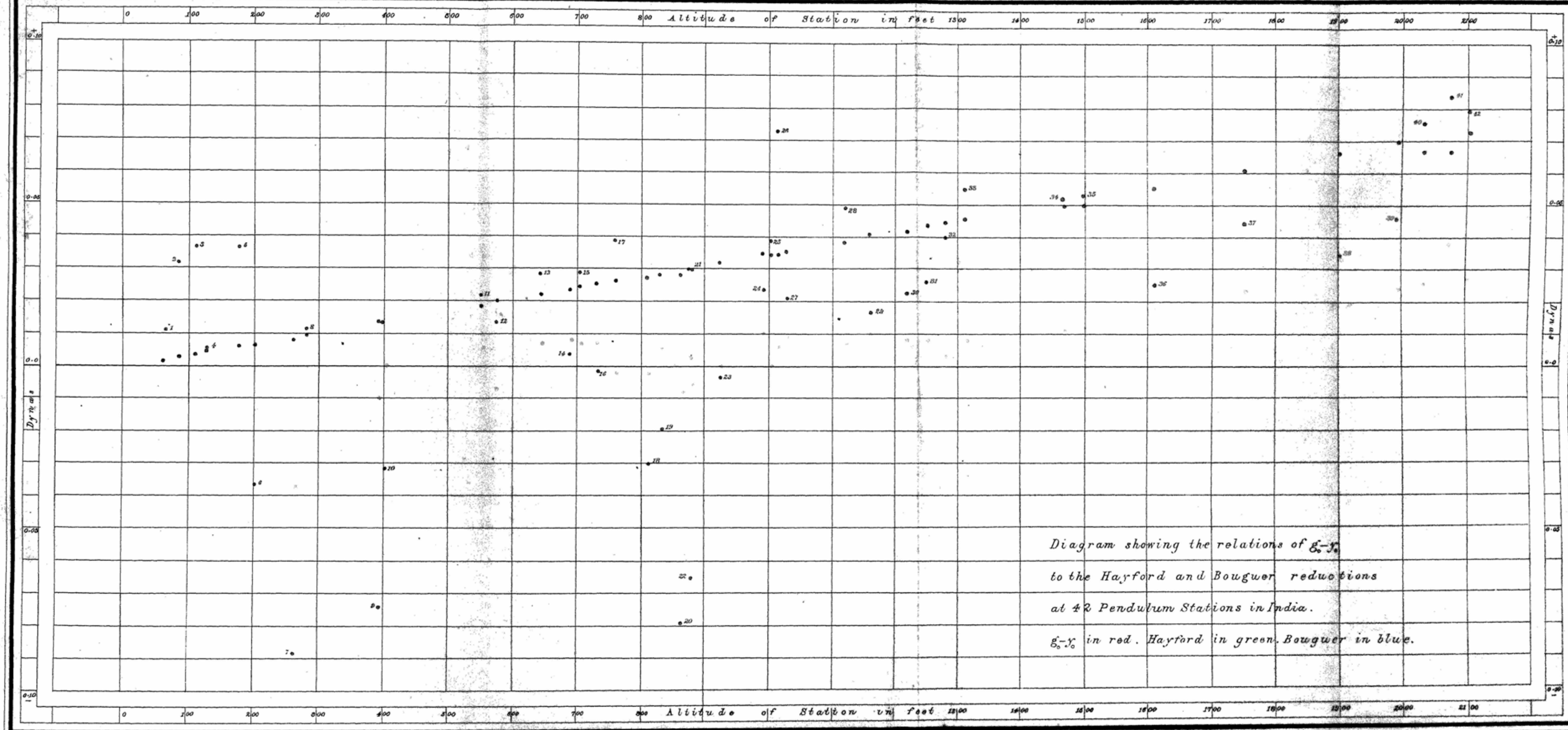
In addition to the latitude work, an attempt was made by Major Crosthwait during the summer, to apply to India the method which Mr. J. Hayford has used in the United States to ascertain whether the condition known as isostasy exists. This involved the computation of the deflection of the plumb-line, in the meridian, due to visible masses up to a distance of 2,564 miles from each station. The deflection was computed for some 100 latitude stations and for 18 longitude stations (in the prime vertical). The details of this work will form the subject of a separate paper. Major Crosthwait's conclusions do not support the Hayfordian theory of isostasy.

The Pendulum Observations.

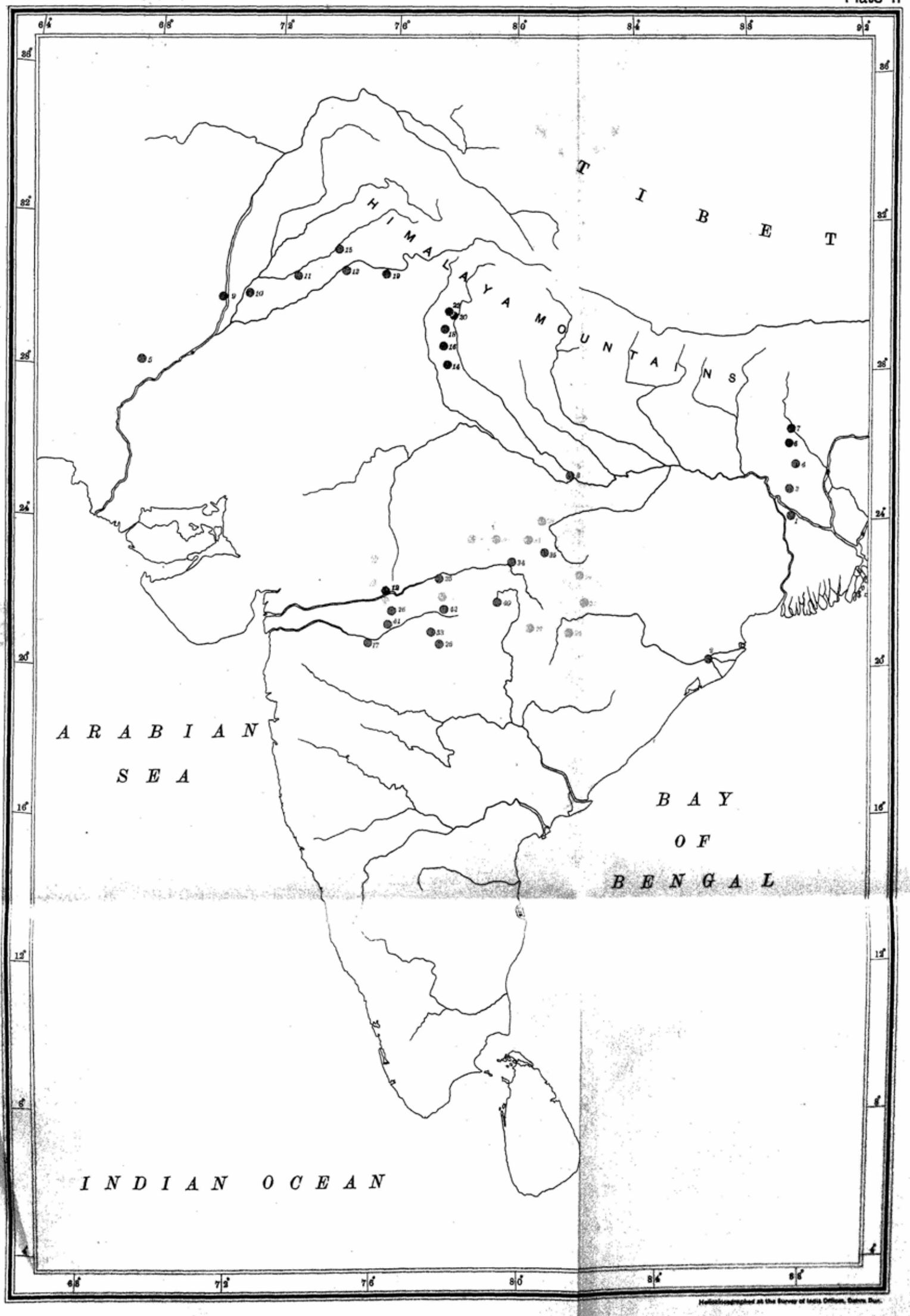
The pendulum operations of 1908-09 and 1909-10 were designed to determine the limits of the areas of high and low crustal density in Central India, the existence of which had been indicated by latitude observations; we particularly wished to discover whether the belt of high density corresponded to any extent with topographical configuration, that is to say, whether it was visible, or whether it lay concealed beneath the surface.

The operations for 1908-09 were confined to the south-western portion of the belt, to the area Ujjain, Dhulia in Khandesh, Amraoti, Hoshangabad. In 1909-10 the pendulums were swung by Captain Cowie in the region to the east of this, in the tract Saugor, Seoni, Bilaspur, and Sultanpur. The work of the two seasons thus covered the area between Lats. 21° to 24° and Longs. 75° to 82°.

The results of the season 1908-09 were communicated in the last report submitted to the Board of Scientific Advice. The stations visited by Captain Cowie in 1909-10 and the results obtained are given in Table 1.



Heliozincographed at the Survey of India Offices, Dehra Dun.



Heliolithographed at the Survey of India Offices, Dehra Dun.

Table 1.

Station.	Latitude.	Longitude.	Height.	Observed value of gravity.
	° ′ ″	° ′	Feet.	Dynes.
Saugor	23 51 47	78 48	1,757	978·731
Damoh	23 49 54	79 26	1,213	978·758
Katni	23 50 25	80 26	1,254	978·757
Umaria	23 31 37	80 54	1,499	978·740
Pendra	22 46 41	82 0	1,996	978·638
Bilaspur	22 3 53	82 12	878	978·681
Raipur	21 13 56	81 41	996	978·612
Amgaon	21 21 31	80 28	1,032	978·614
Seoni	22 5 29	77 29	2,032	978·622
Jubbulpore . . .	23 8 54	79 59	1,467	978·719
Maihar	24 15 38	80 48	1,161	978·784
Allahabad	25 25 55	81 55	288	978·943

The values of gravity given in this table are based on the value of g at Dehra Dun, 979·063 dynes.

The stations are given in the order in which they were visited. At each station four pendulums were swung, and as a rule, four complete sets of observations were made.

In Table 2 are given (i) the observed values of gravity, (ii) these values corrected for height of station, and (iii) for height of station and

mass interposed between station and sea-level according to Bouguer's formula, (iv) the theoretical values of gravity at sea-level, and (v) the comparison of these last values with the observed values reduced to sea-level by means of Bouguer's formula :—

Table 2.

Station.	Observed value of gravity $=g$.	g corrected for height $=g_o$	g corrected for height and mass $=g_o'$	Theoretical value of gravity at sea-level. $=\gamma_o$	$g_o'-\gamma_o$
	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.
Saugor . . .	978·731	978·895	978·834	978·850	—0·016
Damoh . . .	978·758	978·871	978·829	978·848	—0·019
Katni . . .	978·757	978·874	978·830	978·848	—0·018
Umaria . . .	978·740	978·880	978·830	978·827	+0·003
Pendra . . .	978·638	978·824	978·754	978 778	—0·024
Bilaspur . .	978·631	978·763	978·733	978·733	0·000
Raipur . . .	978·612	978·705	978·670	978·681	—0·011
Amgaon . .	978·614	978·710	978·674	978·689	—0·015
Seoni . .	978·622	978·811	978·744	978·735	+0·009
Jubbulpore . .	978·719	978·856	978·806	978·803	+0·003
Maihar . . .	978·784	978·892	978·851	978·877	—0·026
Allahabad . .	978·943	978·970	978·960	978·958	+0·002

In this table the theoretical values of gravity at sea-level have been calculated by Helmert's formula of 1884.

$$\gamma_o = 978{\cdot}000\ [1 + 0{\cdot}005310 \sin^2 \varphi.]$$

The correctness of the Bouguer reduction having been recently questioned by Mr. Tittmann and Mr. Hayford of the U. S. Coast and Geodetic Survey, who uphold the theory of complete isostasy, an investigation has been commenced by Captain Cowie to see whether the gravity results of the Indian Survey support the views of the American Geodesists. This enquiry has progressed only so far as will allow us at present to consider the

masses within 100 miles of 42 stations. The quantities derived from this investigation are given in Table 3.

In reductions of the observed values of gravity to sea-level, the effect of masses situated between the level of the station and sea-level have hitherto been calculated by Bouguer's hypothesis and formula. This hypothesis assumes that in the earth's crust below sea-level there is everywhere a normal amount of matter and that all masses situated above sea-level are in excess of normal. Hayford's hypothesis is based on the theory that in every prism from the centre of the earth to the surface, at whatever distance from the centre that surface may occur, the amount of matter is normal, that is, that where masses are raised above the sea-level, thus constituting excesses of matter above that surface, there must be compensating deficiencies of matter below. Hayford's hypothesis is to the effect that this compensation of mass is everywhere complete and occurs within a stratum situated between the sea-level and a plane 113·7 kilometres below it. In the case of the quantities exhibited in the table, it should be noted that this compensation depth has been assumed to be 70 miles. The hypothesis of Bouguer is, thus, one of no compensation, while that of Hayford maintains complete compensation occurring within a depth of 70 miles below sea-level.

Table 3.

No.	Station.	Height in feet.	Helmert.	Bouguer.	Hayford.	$(g_o - \gamma_o)$ Bouguer.	$(g_o - \gamma_o)$ Hayford.
1	2	3	4	5	6	7	8
1	Chatra . . .	64	11	+ 2	− 1	+ 9	+12
2	Cuttack . . .	92	32	+ 3	− 3	+ 29	+35
3	Kisnapur . .	113	37	+ 4	+ 1	+ 33	+36
4	Ramchandpur . .	132	6	+ 5	0	+ 1	+ 6
5	Jacobabad . .	183	37	+ 6	− 3	+ 31	+40
6	Kesarbari . .	204	36	+ 7	−14	− 43	−22
7	Jalpaiguri . .	268	88	+ 8	−37	− 96	−51
8	Allahabad . .	288	12	+10	0	+ 2	+12

Table 3—contd.

No.	Station.	Height.	Helmert.	Bouguer.	Hayford.	$(g_o - \gamma_c)$ Bouguer.	$(g_o - \gamma_c)$ Hayford.
1	2	3	4	5	6	7	8
9	Dera Ghazi Khan .	397	74	+14	−10	− 88	−64
10	Multan . . .	404	31	+14	0	− 45	−31
11	Montgomery . .	557	22	+19	+ 6	+ 3	+16
12	Mortakka . .	576	14	+20	− 7	− 6	+21
13	Ferozepore . .	646	29	+23	+ 7	+ 6	+22
14	Gesupur . . .	691	4	+24	+ 8	− 20	− 4
15	Mian Mir . .	708	29	+25	+ 7	+ 4	+22
16	Meerut . . .	734	1	+26	+ 7	− 27	− 8
17	Jalgaon . . .	760	39	+27	− 2	+ 12	+41
18	Kaliana . . .	810	30	+28	− 2	− 58	−28
19	Ludhiana . .	835	19	+29	+ 5	− 48	−24
20	Roorkee . . .	867	78	+29	− 8	−107	−70
21	Bilaspur . . .	878	30	+30	+ 3	0	+27
22	Nojli . . .	879	65	+30	− 6	− 95	−59
23	Mukhtiara . .	926	3	+32	0	− 35	− 3
24	Raipur . .	996	24	+35	+10	− 11	+14
25	Hoshangabad . .	1,002	39	+35	0	+ 4	+39
26	Khandwa . .	1,014	73	+35	+ 6	+ 38	+67
27	Amgaon . . .	1,032	21	+36	+ 9	− 15	+12
28	Amraoti . . .	1,123	49	+39	+ 7	+ 10	+42
29	Maihar . . .	1,161	15	+41	+10	− 26	+ 5
30	Damoh .	1,213	23	+42	+ 8	− 19	+15
31	Katni . . .	1,254	26	+44	+ 8	− 18	+18

Table 3—contd.

No.	Station.	Height in feet.	Helmert.	Bouguer.	Hayford.	$(g_o - \gamma_o)$ Bouguer.	$(g_o - \gamma_o)$ Hayford.
1	2	3	4	5	6	7	8
32	Shahpur . .	1,284	40	+45	+ 3	− 5	+37
33	Ellichpore . .	1,314	55	+46	+ 8	+ 9	+47
34	Jubbulpore . .	1,467	53	+50	+11	+ 3	+42
35	Umaria . . .	1,499	53	+50	+12	+ 3	+41
36	Ujjain . . .	1,612	25	+56	+18	− 31	+ 7
37	Saugor . . .	1,757	45	+61	+23	− 16	+22
38	Mhow . . .	1,903	34	+67	+33	− 33	+ 1
39	Pendra . . .	1,996	46	+70	+24	− 24	+22
40	Seoni . . .	2,032	76	+67	+25	+ 9	+51
41	Asirgarh . . .	2,077	84	+67	+38	+ 17	+46
42	Badnur . . .	2,103	79	+73	+27	+ 6	+52
	Mean positive . .	.....	36	.....	+13	+ 12	+28
	„ negative .	.....	43	.....	− 9	− 40	−33
	General mean . .	.....	17·5	+32·7	+ 5·7	− 15·2	+11·9

In this table the unit is the thousandth part of a dyne.

The Hayford method has been applied to masses within 100 miles of the station. An extension of this investigation to cover the whole surface of the globe would result in a small correction, negative in sign, but varying slightly in amount, being applied to two quantities in column 6.

The figures in columns 4, 5 and 6 of the Table all profess to represent the same quantity, the effect of masses in the neighbourhood of each station on the force of gravity. The first of the three columns gives the actual effects of these masses as derived from a comparison of the observed value of gravity, corrected for altitude of station only, with the theoretical value g_o at sea level. The two succeeding columns give the theoretical effects based on the two hypotheses of Bouguer and Hayford.

The Hayford correction tends to increase the observed value of gravity. In a region, like the Sub-Himalayan, where large negative values of $(g_o - \gamma_o)$ prevail, the Hayford correction does reduce the anomalies of column 7. But in a region, like the Indo-Gangetic plains, where positive values of $(g_o - \gamma_o)$ have been found at all stations throughout a long zone, the Hayford correction serves only to intensify the anomalies.

Tidal Operations.

During the past year tidal registrations by automatic tide gauges have been taken at the ports of Aden, Karachi, Apollo Bandar (Bombay), Prince's Dock (Bombay), Madras, Kidderpore, Rangoon, Moulmein and Port Blair. The registrations at these ports have been satisfactory.

Levelling Operations.

The total outturn of double levelling of precision completed during the field season 1909-10 was 1,276 miles, in the course of which observations were taken at 16,944 stations. The bench-marks determined were 41 standard, 134 rock-cut, 1 interred, 7 engraved, 90 embedded, 343 inscribed, and 64 belonging to other departments.

The heights of 21 Principal and 3 Secondary triangulation stations were also determined by levelling as a check on the heights deduced by triangulation. The principal lines of levelling were carried on in the Bahawalpur State, the Punjab, Sind, the Sub-Himalayan tracts and in Burma; there were also short lines of levelling in other parts of India in connection with the standard bench-mark scheme.

The following are the Himalayan lines of levelling that were completed during the past field season :—

1. Lahore to Dharamkot, *viâ* Pathankot and Dharamsala.
2. Hardwar to Lansdowne, *viâ* Najibabad.
3. Bareilly to Naini Tal Brewery, *viâ* Kathgodam.
4. Siliguri to Tindharia.

BOTANICAL SURVEY.

BY

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Eastern India.—Work on the Catalogue of the non-herbaceous flowering plants cultivated in the Royal Botanic Garden, referred to in last year's report has been continued. The numerical index to the first 4,000 plants together with a new map of the Garden to serve as a key to the position of the plants therein is about to appear and another 4,000 numbers are ready for press.

Reference was made last year to the expedition then in progress of Messrs. Smith and Cave to the extreme north-west of Sikkim. The results of this tour have been elaborated by Mr. Smith in a paper that is now in the press and will appear as No. 5 of Vol. IV of the Records of the Botanical Survey. The following condensed account of the results is taken from Mr. Smith's manuscript. The expedition lasted during July and August of 1909, and the immediate result was some 6,000 specimens with about a score of species new to science. The Zemu and Llonakh valleys are the most distant from the main roads and most difficult of access on account of the dense Rhododendron jungle and high passes that cut them off from the rest of Sikkim. There are neither houses, roads, bridges nor even pony tracks. Botanically the Zemu area shows three regions—a temperate forest region from 8-11,000 feet, a sub-alpine shrub region from 11-14,000 feet and an alpine region from 14-17,000 feet. In the first region are found such genera as *Picea, Larix, Tsuga, Abies, Juniperus* with numerous species of *Berberis, Ilex, Euonymus, Acer, Rubus, Rosa, Spiræa, Pyrus, Ribes, Viburnum, Lonicera, Rhododendron, Corylus, Betula, Alnus,* etc. Towards the upper limit of the region Rhododendrons and Coniferæ prevail. At about 11,000 feet the tall Rhododendrons tend to disappear and are replaced by intermediate forms like *R. Wightii* and *R. campanulatum. Coniferæ* begin to thin off and the valley opens out. At about 12,000 feet most of the trees disappear and the floor of the upper valley is covered with straggling shrubs of *Berberis, Pyrus, Cotoneaster, Ribes, Lonicera, Rhododendron* and *Salix.* The herbaceous element is represented by species of *Meconopsis, Cardamine, Corydalis, Lychnis,*

Astragalus, Potentilla, Sedum, Epilobium, Heracleum, Angelica, Saussurea, Primula, Pedicularis, Salvia, Polygonum, etc. From 14-18,000 feet the prevailing genera are *Anemone, Corydalis, Draba, Potentilla, Saxifraga, Sedum, Cremanthodium, Saussurea, Leontopodium, Anaphalis, Primula, Androsace, Gentiana, Swertia, Lagotis, Pedicularis, Polygonum, Salix, Carex, Poa.* Taken as a whole the valley shows a transition from the moist prolific areas such as Jongri to the south, to the dry area beyond the Thé La. Generally speaking the vegetation of the Zemu has more affinity with that of Jongri than with that of Llonakh.

The Llonakh valley is a wide expanse of gently undulating ground in the midst of the highest peaks, with here and there huge moraines on the flanks. The flats show evidence of strong persistent winds, the vegetation being chiefly of the "tussock" type. The subsidiary valleys are characterised by a succession of flats and marshes, the upper ends of the valleys ending in cliffs and glaciers. The vegetation of the Llonakh valley as a whole may be divided into (1) the plants of the open flats and marshes, (2) the plants of the moraines and screes, (3) the extreme alpines of the upper cliffs. On the flats trees and shrubs are restricted to dwarfish specimens of Juniper, *Rhododendron lepidotum* and *R. Anthopogon, Berberis, Spiræa, Potentilla fruticosa, Lonicera, Hippophæ*, and an occasional *Salix*. Among the herbaceous species the hemispherie mounds of *Arenaria* are the most striking. On the moister areas flourish species of *Ranunculus, Caltha,* and *Pedicularis, Poterium filiforme, Saxifraga pallida, Primula sikkimensis,* and *P. tibetica.* On the drier flats were found species of *Delphinium, Hypecoum, Lepidium, Stracheya, Astragalus, Oxytropis, Saussurea, Artemisia, Campanula, Cyananthus, Urtica, Allium,* and such species as *Arabis glandulosa, Viola kunawarensis, Stellaria decumbens, Saxifraga flagellaris, Antennaria muscoides, Anaphalis xylorhiza, Androsace Selago, Lancea tibetica, Elsholtsia eriostachya*, etc. Amongst the screes in addition to the Junipers and dwarf Rhododendrons were species of *Anemone, Callianthemum, Draba, Saxifraga, Sedum, Trigonotis, Onosma, Picrorhiza, Eriophyton, Polygonum tortuosum.* On the higher cliffs the prevalent plants were *Meconopsis horridula, Draba, Braya, Thlaspi, Cochlearia, Potentilla macrophylla, P. fruticosa, Saxifraga imbricata, S. ranulosa, S. saginoides, Cortia, Allardia, Saussurea, Primula muscoides, Androsace, Selago, Myosotis Hookeri, Veronica lanuginosa, Polygonum nummularifolium, P. Hookeri, Rheum nobile, R. spiciforme.*

Considering the north-west corner of Sikkim as a whole and the vegetation above 11,000 feet, *Ranunculaceæ* are only moderately represented,

Berberis persists into the upper Llonakh valleys. *Meconopsis* is well represented in quantity. *Corydalis* is prevalent and rich in species. *Drabas* chiefly represent the Cruciferæ. *Lychnis, Stellaria* and *Arenaria* are strong in species and in numbers. *Impatiens* persists only as far as the lower Zemu. *Leguminosæ*—chiefly *Astragalus* and *Oxytropis*—are but moderately frequent in the upper regions. *Potentillas* are very conspicuous and abundant. *Saxifraga* is also a dominant genus, nearly all the Himalayan species being found in the area. *Umbelliferæ* are not particularly prominent. *Compositæ*, especially *Saussureas* are abundant. *Codonopsis* and *Cyananthus* are frequent. Rhododendrons abound but are not of many species. *Primulaceæ* are particularly common, as are species of *Pedicularis*. *Salix* prevails up to the melting snows. Rushes, sedges and grasses are poorly represented. In addition to the new species that are described in Mr. Smith's paper, nearly forty species have been added to the list of plants native to Sikkim.

In addition to his account of the vegetation of Llonakh, Mr. Smith has also described several new species of Eastern Himalayan plants from the collections made by Mr. J. C. White, C.I.E., late Political Officer in Sikkim. These will appear along with the Llonakh paper.

Collections from the lower and outer hills of the Eastern Himalaya have been contributed by the late Mr. R. Pantling, Assistant-Superintendent of the Cinchona Plantation, by Mr. G. E. Shaw, B.Sc., F.I.C., Government Quinologist, and by Mr. R. E. Cooper.

In Eastern Bengal and Assam collections were made by trained Lepcha collectors in the Terai of the Jalpaiguri district.

From Burma large accessions of material were received. Mr. J. H. Lace, F.L.S., Chief Conservator of Forests, sent a finely preserved collection of about 1,000 specimens that have helped largely to fill up gaps or to supplement species previously very imperfectly represented in the Calcutta Herbarium. Important contributions that include species hitherto undescribed were also received from Captain R. W. MacGregor, I.M.S., from the Southern Shan States and from the following Deputy Conservators of Forests: Mr. G. E. S. Cubitt of Bhamo, Mr. H. W. A. Watson of the Southern Shan States, Mr. A. Rodger of the Ruby Mines, and Mr. E. M. Buchanan of Myitkyina. Mr. D. W. Rae, Assistant Superintendent, Kachin Hills, forwarded a collection of ferns from Sinlumkaba. To all these officers the Botanical Survey is much indebted. From the Burma-Yunnan frontier a particularly fine collection

of over 1,000 sheets was obtained from Mr. G. Forest, well known for his botanical explorations in China.

A suggestive and most interesting account of Recent Plant Immigrants into Bengal has been published by Mr. P. J. Brühl, F.G.S., F.C.S., of the Indian Educational Service. His paper is divided into two parts, the first being concerned with the description and distribution of *Croton sparsiflorus* Morung, in Bengal. This species, a native of South America, appears to have been first imported into Chittagong, where it was collected in 1898, and thence have spread up the Megna and across to the mouths of the Hughli. It was observed at Diamond Harbour and other places down the Hughli river by Botanic Garden collectors in 1903 and in the following year was collected at Sibpur. Mr. Brühl gives an account of its present distribution as determined by himself in the neighbourhood of Sibpur and further afield, and points out how excellent an example of the dispersal of a species the further spread of *Croton sparsiflorus* will afford. The second and the larger part of Mr. Brühl's paper deals with those species found in Bengal and Behar that are known to be immigrants from other countries. It is pointed out how the agricultural conditions of Bengal and Behar favour the introduction and spread of foreign species. Mr. Brühl gives a list of 234 species of foreign origin now more or less established in the province, representing 166 genera and 58 orders, the names of some of the latter, however, by some slip having been omitted in the paper.

The immigrants hail from practically all quarters of the globe, from temperate Europe, Western Asia and Songaria; Japan, China and Indo-China, the Malayan Peninsula, Andaman Islands, and Ceylon; the Malayan Archipelago and the Philippines, Polynesia, Africa and the African islands, the United States, tropical and sub-tropical America in general, Mexico and Central America, the West Indies, the Andes region, Brazil, the La Plata region. Mr. Brühl gives a list of the species and the percentage of the whole contributed by each region. More than half the total of introduced species has been furnished by America, Asia (except the N.-W.) outside of India coming next, then Europe and Asia N.-W. of India with a considerable drop and last of all Africa. A list is given showing what orders have been enriched and to what extent by the immigrants. Mr. Brühl concludes that the immigrants furnish 12·4 per cent. of the Flora of Bengal and Behar. He suggests the way in which these species have been introduced by classifying them in detail according as to whether they are cultivated (field crops, garden plants, forest, avenue and hedge plants) or wild (field and garden weeds, weeds of grass plots, road-

sides and waste places, plants found in tanks and marshes). Mr. Brühl also indicates approximately the periods of introduction of the various species from before the arrival of the Portuguese in India in 1498 to after 1897. The dissertation ends with an account and classification of the Bengali names given to the introduced species, and a plea for the establishment of local herbaria in district centres.

Western India.—The outstanding feature of the year's work on this side of India is the appearance of the first volume of an illustrated Forest Flora of the Bombay Presidency and Sind by Mr. W. A. Talbot, F.L.S., late Conservator of Forests. The book is a large volume of over 500 pages, with 288 sketch figures in the text. The natural orders concerned are from *Ranunculaceæ* to *Rosaceæ*. The work affords the opportunity of comparing the number of arborescent species as they appeal to the Forest officer with the total number of species within the same ordinal limits as given in Dr. T. Cooke's Flora of the Presidency of Bombay, the first volume of which containing amongst others the same orders dealt with by Mr. Talbot appeared in 1903. From *Ranunculaceæ* to *Rosaceæ*, both included, 49 orders appear in the Flora with 303 genera and 769 species. In the Forest Flora there are ten orders fewer, while the genera drop to 207 and the species to 439. The ten dropped orders are *Nymphæaceæ*, *Papaveraceæ*, *Fumariaceæ*, *Cruciferæ*, *Polygalaceæ*, *Caryophyllaceæ*, *Portulacaceæ*, *Elatinaceæ*, *Hypericaceæ*, and *Zygophyllaceæ* with a total of 48 species. Of the orders common to both works those that show marked differences in the number of genera and species in the two works, being such as show a fair proportion or even a predominance of herbaceous species the difference between the generic and specific numbers in such orders roughly indicates the saving to the Forest Officer who desires to know the plants that more immediately concern him without first having to sort out the herbaceous species. The more important among such orders are *Capparidaceæ*, that in the Forest Flora are shorn of three genera and thirteen species; *Malvaceæ* that are reduced from 16 genera with 67 species in the Flora to eight genera and only 12 species in the Forest Flora; *Sterculiaceæ* with 9 genera and 24 species to 6 genera and 13 species; *Tiliaceæ* with 5 genera and 34 species in the Flora to 3 genera and 20 species in the Forest Flora; *Geraniaceæ* from 6 genera with 23 species to 1 genus with 2 species. Absolutely, though not relatively, the greatest reduction occurs in the large order *Leguminosæ*, which is reduced from 81 genera with 284 species in the Flora to 49 genera with 136 species in the Forest Flora. A few other orders of minor importance

shed a genus or a species or two. On the other hand one or two orders in the Forest Flora show an increase of species or genera over the numbers shown in the Flora. Thus the order *Guttiferæ* in the Forest Flora is credited with 11 species, while the Flora gives only ten. The difference in this case is due to Mr. Talbot raising a variety of *Garcinia spicata* in the Flora to specific rank in the Forest Flora. In the Forest Flora the order *Olacaceæ* shows an additional genus and species *Erythropalum populifolium* Mast. that is not given in the Flora. In Anacardiaceæ *Holigarna ferruginea* March., appears as an extra species in the Forest Flora, no mention being made of it in the Flora. In *Connaraceæ, Rourea Prainiana* and in *Celastraceæ, Gymnosporia konkanensis* new species are described in the Forest Flora. Mr. Talbot describes four distinct types of Forest Flora within the Presidency and Sind : (1) the evergreen tropical flora of distinct Malayan Peninsular origin, (2) the mixed deciduous and evergreen Konkan flora, (3) the mixed deciduous Deccan flora, and (4) the Sind desert flora. Evergreen tropical or Rain-forests are found with a rainfall of not less than 70 inches per annum in North Kanara, and further north in isolated patches into Dharwar. These forests are practically absent from the Deccan trap, and their total extent in the Bombay Presidency does not cover more than 500 square miles. The mixed deciduous and evergreen or Monsoon-forest extends in an irregular and interrupted belt about 500 miles long and about 40 miles wide from Bombay to North Kanara, and constitutes the bulk of the Konkan flora. It requires a rainfall of not less than 40 inches per annum. The mixed deciduous Deccan flora consists of an open formation of thorn-forest, a name that indicates one of its prominent features. A remarkable feature of the desert flora of Sind is the forest formation of *Prosopis spicigera* L. that occurs near the river Indus above the level of inundation.

Mr. G. A. Gammie, F.L.S., has given an account of the Orchids of the genera *Vanda, Saccolabium, Sarcanthus, Cleisostoma* and *Diplocentrum.* Two species of *Vanda, V. parviflora* Lindl. and *V. Roxburghii* R. Br. occur in the Presidency, while Mr. Gammie has described a new variety *Spooneri* of the latter species. Three species of *Saccolabium* are found, *S. Wightianum* Hook. f., *S. viridiflorum* Lindl. and *S. maculatum* Hook. f. The other three genera are represented by one species of each, *Sarcanthus peninsularis* Dalz., *Diplocentrum congestum* Wight and an unnamed species of *Cleisostoma,* materials of which were collected by Mr. Gammie in North Kanara previous to 1902, but were unfortunately lost by fire.

Two coloured plates accompany the descriptions, one of *Vanda Roxburghii*, the other of *Saccolabium Wightianum*.

Mr. L. J. Sedgwick, I.C.S., has published a first list of mosses from Western India. Altogether 35 species and 28 genera are represented, while three of the species are new to science.

The Rev. Father E. Blatter, S.J., has given a general account of the vegetation with a sketch map of the physical features, and a detailed list of the species of Panchgani, a small station about 12 miles east of Mahableshwar on the Western Ghats. He divides the station into four regions, each characterised by its flora. A list of some 368 species of flowering plants belonging to 89 natural orders, with the habitat within Panchgani of each species, and vernacular or English names in most cases is given. A list of 14 ferns belonging to ten genera is also appended.

Mr. W. Burns, B.Sc., Economic Botanist to the Government of Bombay, has collected in the Dharwar and Broach districts and has studied the plant life of certain limited areas in relation to environment. He has given attention to the genera *Mangifera* and *Tamarix* as they occur in the Bombay Presidency. Messrs. Chibber and Bhide, Assistants to the Economic Botanist, toured through various districts of the Presidency and made collections chiefly of grasses. About 1,000 sheets were added to the local herbarium.

Southern India.—The only work of systematic importance during the year has been done by Mr. C. E. C. Fischer, Deputy Conservator of Forests, Coimbatore, who has continued his researches on the flora of that part of India and has contributed several hundreds of excellently preserved specimens to the Calcutta Herbarium, that should be very useful in the ultimate working out of the flora of the Madras Presidency.

North-West India.—During the year Mr. J. F. Duthie, B.A., F.L.S., has forwarded the final instalment of manuscript of Volume II of the Flora of the Upper Gangetic Plain, and the whole of Volume II is now in type.

Mr. I. H. Burkill, M.A., F.L.S., Reporter on Economic Products to the Government of India, has given an account in the Records of the Botanical Survey, Volume IV, No. 4, of the vegetation of the route traversed by him in the end of 1907 when he visited Khatmandu, and has given a list of the species collected or observed on the way. His paper is accompanied by a map showing the route traversed. Mr. Burkill describes the belts of vegetation traversed by the road, the great Bhavar or Sal forest under the mountains, the waste grass lands of the Terai, the pine woods on the south

face of the foot-hills, the vegetation about the top of the foot-hills, the plants of the northern aspect of the same, and the forest on the outer face of the inner hills. A list of the plants of the tropical Forest belt is given, a brief account of the crops cultivated, and another list of wild plants of the cultivated belt. The vegetation of the temperate Forest belt is described and a list of the plants observed therein is given. The general conclusions arrived at by Mr. Burkill are that the Sal forests of the tropical belt are rather more eastern than western in character, that the pine forests on the south face of the forest hills are unrepresented in Sikkim although a few of their plants are distinctly eastern; that the Sal forests on the northern slopes of the foot-hills near Hettaunda are like the Sal forests of the lower Sikkim-Himalayan slopes; that the vegetation of the wet gorge of Bhainsa Duhan agrees closely with that of corresponding localities in Sikkim; that vegetation of the cultivation belt differs somewhat from the vegetation of the same belt in Sikkim; that the plants of the wet hill tops agree with those of similar places in Sikkim. The endemic species found by Mr. Burkill numbered five, possibly six. The total number of species of flowering plants enumerated is 584, belonging to 403 genera and 109 orders. In addition, 13 species of ferns belonging to 9 genera, a Lycopod and an Equisetum are recorded. Mr. Burkill's specimens have been presented by him to the Calcutta Herbarium.

Further west Mr. James Marten has given an account of the flowering plants in and about Mussoorie collected by him during 1908, with notes on the periods of flowering and uses. Excluding *Cyperaceæ* and *Gramineæ* and some smaller orders after *Araceæ* that Mr. Marten does not mention he enumerates 313 species belonging to 235 genera and 81 orders. The predominant orders are *Leguminosæ, Urticaceæ, Compositæ, Rosaceæ, Orchidaceæ, Euphorbiaceæ, Labiatæ, Tiliaceæ.*

From Kumaon considerable collections were contributed by Mr. N. Gill, F.L.S., Superintendent of the Government Gardens there, and from Simla and its neighbourhood by Mr. A. R. Tucker, late of the Revenue and Agricultural Department. Colonel C. J. Bamber, I.M.S., F.L.S., has continued his useful descriptive key to the plants of the Punjab, North-West Frontier Province and Kashmir, two more instalments having appeared during the year.

General.—The Rev. Father Blatter, S.J., has published the first of a series of articles on "The Palms of British India and Ceylon, indigenous and introduced." In his first paper Father Blatter gives a short history of the exploration of the Indian Palm-flora, and a general account of the

morphology and geographical distribution of the order. A list of palm genera is followed by an account of the distribution of palms in British India, and a bibliographical list. The paper is illustrated with a plate and a sketch map of the geographical distribution.

Mr. I. H. Burkill has given a general account with figures of the genus *Coptis* belonging to the natural order *Ranunculaceæ* and a detailed study of the origin of Coptis, a drug that is of some repute for its tonic properties. Three kinds of the root are imported into India, one sort from the Mishmi hills and two kinds by sea. Mr. Burkill's conclusions are that the supply of the drug obtained from the Mishmi hills in Assam is the product of *Coptis Teeta* Wall., that the plant cultivated in China as a source of the drug is a variety of *C. Teeta*, that in Japan another species *C. anemonæfolia* Sieb. & Zucc. both wild and in cultivation appears to yield a medicinal product, while still another species allied to the last but not yet satisfactorily discriminated would also seem to be employed as a curative agent. Mr. Burkill thinks it probable that one of the two sorts of Coptis brought to India by sea is the product of the Chinese variety of *C. Teeta* and that the other is yielded by *C. anemonæfolia* of Japan.

Mr. Burkill has also described two varieties of the grass *Cymbopogon Martini* Stapf. that occur in Berar, yielding two kinds of volatile oil. The two varieties are *Motia* and *Sofia*, the former distinguished by the absence of a strong smelling substance known as i-carvon, which is present in the latter. Botanically the varieties differ in their habitats and in the angles at which their leaves are set on to their sheaths.

Mr. A. W. Hill, M.A., F.L.S., of the staff of the Royal Botanic Gardens, Kew, has given an account of the genus *Myxopyrum* of the order *Oleaceæ*, in which he describes ten species of which two are Indian, the latter including a new species *M. serratulum* A. W. Hill, from Travancore and the Anamalai hills of Southern India. Mr. Hill expresses the opinion that the Indian species show greater affinity to the species of New Guinea and the Kei Islands than to the species of the Malayan Peninsula and Archipelago.

Mr. W. B. Hemsley, F.R.S., has cleared up the confusion that has hitherto existed regarding the species called *Cornus macrophylla* Wall. and has described some Asiatic species of the same genus. Mr. Hemsley distinguishes two new Indian species, *C. controversa* Hemsl. from the Eastern Himalaya and Manipur, and *C. Stracheyi* Hemsl. from Kumaon in the North-Western Himalaya, both of which have hitherto been confused with *C. macrophylla* Wall.

M. Beauverd has published descriptions of *Leontopodium Jacotianum* and *L. evax*, new species of *Compositæ* found in both Western and Eastern Himalaya. The same Botanist has also described the following new species of the genus *Cicerbita* :—*C. Duthieana, C. laevigata, C. violæfolia, C. decipiens, C. macrantha, C. Aitchisoniana*, mostly from the Himalayan region.

The following new species of the order *Compositæ* from the Eastern Himalaya have been described by Mr. J. R. Drummond, I.C.S. (retd.) :—*Anaphalis deserti, Leontopodium fimbrilligerum, L. paradoxum, Saussurea tanguensis.* A new species of *Corydalis* from the same region that had been named in the Calcutta Herbarium *C. spathulata* by Colonel Prain has been described by Mr. Craib.

Micholitzia obcordata, a new genus and species of the order Asclepiadaceæ from India, has been described by Mr. N. E. Brown, but its precise habitat within India was unknown at the time of description. It has, however, been collected by Mr. A. Meebold at Laimatak in Manipur. Mr. R. A. Rolfe has published a new orchid *Saccolabium platycalcaratum* from Upper Burma. Coloured plates of the following Indian species have appeared in the Botanical Magazine *Peliosanthes violacea* VAR. *Clarkei* Baker, *Pieris formosa* D. Don., *Scutellaria violacea* Heyne, *Iris Clarkei* Baker. From the Malayan Peninsula the following new species have been recorded and described :—*Eria ochracea* and *Acriopsis latifolia*, new orchids by Mr. Rolfe, *Derris Yappii*, a new Leguminous plant by Mr. W. G. Craib, *Vernonia Curtisii*, a new Compositæ by Messrs. Craib and Hutchinson, *Aristolochia Curtisii* and *A. minutiflora* by Mr. J. S. Gamble, the former of which had been named in manuscript by the late Sir George King and the latter by Mr. H. N. Ridley.

Mr. Gamble has also described six new species of *Cryptocarya*, ten new species of *Beilschmiedia*, ten new species of *Dehaasia* and three new species of *Endiandra* from the same region.

Selected list of Papers on the Botany of India published during 1909-10.

ADAMSON, R. S. . Note on the roots of *Terminalia Arjuna* Bedd. (*New Phyto., 1910, ix, 150.*)

BAMBER, C. J. . . Plants of the Punjab. (*Journ. Bomb. Nat. Hist. Soc., 1909-10, xix, 370, 683, 943.*)

BEAUVERD, G. . . Contribution à l'etude des Composées Asiatiques. (*Bull. Soc. Bot. Genève, 1909.*)

BLATTER, E. . . The Flora of Panchgani. (*Journ. Bomb. Nat. Hist. Soc., 1909, xix, 314.*)

BLATTER, E. . . The Palms of British India and Ceylon, indigenous and introduced. (*Journ. Bomb. Nat. Hist. Soc., xx, 33, with plate and map.*)

BROWN, N. E. . . *Micholitzia obcordata* N. E. Brown. (*Kew Bull., 1909, No. 9, 358.*)

BRÜHL, P. J. . . Recent Plant Immigrants. (*Journ. Asiat. Soc. Beng., iv, 2, 603.*)

BURKILL, I. H. . First Notes on *Cymbopogon Martini* Stapf. (*Journ. Asiat. Soc. Beng., v, 89.*)

On Coptis. (*Journ. Asiat. Soc. Beng., v, 73.*)

CLARKE, C. B. . . New Genera and Species of *Cyperaceæ*. (*Kew Bull., Add. Ser. viii, 1908.*)

Illustrations of *Cyperaceæ*. (*Plates 144, London, 1909.*)

DUBARD, M. . . Les Sapotacées du groupe des Isonandrées. (*Rev. Gen. Bot., 1909, xxi, 392.*)

Sur les Isonandrées des Indes orientales. (*Bull. Mus. Nat. Hist., Paris, 1909, 27.*)

DRUMMOND, J. R. . *Anaphalis deserti, Leontopodium fimbrilligerum, Leontopodium paradoxum, Saussurea tanguensis.* (*Kew Bull., 1910, 76-78.*)

ENGLER, A. . . Die Bedeut. der Araceen für die Pflanzengeograph. gleider des tropischen und extratropischen Ostasiens. (*Sitzber Kgl. preuss. Ak. Wiss., lii, 1909.*)

GAGNEPAIN, F. . . Bixacées et Pittosporées asiatiques. (*Bull. Soc. Bot. France, 1908. lv, 521, 544.*)

Essai de classification des *Scolopia* et *Flacourtia* asiatiques. (*Journ. Bot., 1908, xxi, 164.*)

Essai d'une classification des *Cratoxylon* asiatiques. (*Notul. System. 1909, 14.*)

Essai d'une classification des *Sida* asiatiques. (*Notul. System. 1909, 27.*)

Nouveautés asiatiques de l'herbier du Museum. (*Bull. Soc. Bot. France, lvi, 1909, 15, 35.*)

GAMMIE, G. A. . Orchids of the Bombay Presidency, Parts IX & X. (*Journ. Bomb. Nat. Hist. Soc., 1909, xix, 624, xx, 126, with 3 plates.*)

GEHRMANN, K. . Die geograph. Verbreit. und Entwick. der Gattung *Bridelia*. (*Jahrber. Schlesisch. Ges. vaterl. Kultur, lxxxvi, 1909, 28.*)

GOEBEL, K. . *Monoselenium tenerum* Grif. (*Fl. Allgem. Bot. Zeit., 1910, 45.*)

HAMET, R. . *Sedum Prainii, S. Lenii, S. Liciæ* sp. nov. (*Bull. Soc. Bot. France, lvi, 1909, 566.*)

HEMSLEY, W. B. . *Cornus macrophylla* and some Asiatic congeners. (*Kew Bull., 1909, 8, 329.*)

HILL, A. W. . The Genus *Myxopyrum*. (*Kew Bull., 1910, 40.*)

HOOKER, J. D. . Les especes du genre "Impatiens" dans l'Herbier du Museum de Paris. (*N. Arch. Mus. Hist. Nat., 1909, x, 2, 233, with plates.*)

JOWITT, J. F. . Note on Dr. Otto Stapf's Nomenclature of *Cymbopogon Nardus* Rendl., and *C. confertiflorus* Stapf. (*Ann. Roy. Bot. Gard. Peraden. 1908, iv, 185.*)

KRAUTTER, L. . A comparative study of the genus *Pentstemon*. (*Contr. Bot. Lab., Univ. of Philadelphia, 1908, iii, 93.*)

KUSANO, S. . Further studies on *Æginetia indica*. (*Bull. Coll. Agric. Tokyo Imp. Univ., 1908, viii, 1.*)

MARTEN, J. . Plants gathered in and about Mussoorie during 1908. (*Journ. Bom. Nat. Hist. Soc., 1909, xix, 475.*)

PRAIN, D. . *Corydalis spathulata*. (*Kew Bull., 1910, 73.*)
Rheum inopinatum, Prain. (*Bot. Mag., 1908, Tab. 8190.*)

RADLKOFER, L. . Ueber die Gattung *Allophylus* und die Ordnung ihrer Arten. (*Sitzber. Math-Phys. Klasse Kgl. bayer. Ak. Wiss., 1908, 201.*)

ROLFE, R. A. . *Saccolabium* (*Calceolaria*) *platycalcaratum* Rolfe. (*Kew Bull., 1909, 368.*)

SCHWERIN, F. V. . Monographie der Gattung *Sambucus*. (*Mitteil. der Deutsch Dendrolog. Gesell, 1909, p. 1.*)

SEDGWICK, L. I. . A first List of Mosses from Western India. (*Journ. Bom. Nat. Hist. Soc., 1910, xix, 938.*)

SERVETTAZ, C. . Monographie des Eleagnacées. (*Beihefte Bot. Centralbl. Bd., 1909, xxv, pp. 1 & 129.*)

SKAN, S. A. . *Scutellaria violacea* Heyne. (*Bot. Mag., 1910, Tab. 8320.*)

SPRAGUE, T. A. . *Chirita barbata* Sprague. (*Bot. Mag., 1908, iv, 42, Tab. 8200.*)

TALBOT, W. A. . Forest Flora of the Bombay Presidency and Sind. (*Poona, 1909, 508 pages with numerous figures.*)

WOLF, T. . Über die neue "Monographie der Gattung Potentilla." (*Isis, 1908, 52.*)

WRIGHT, C. H. . *Peliosanthes violacea* Wall. VAR. *Clarkei.* (*Bot. Mag. 1909, Tab. 8276.*)

ECONOMIC BOTANY.

BY

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In accordance with the practice of previous years this report deals only with original contributions to the Economic Botany of India which have been published or are in course of publication during the year under review, in this case the year ending June 30th, 1910. The programmes of work in this subject are given in detail in the last issue of the *Proceedings of the Board of Agriculture in India* and an abstract is to be found at the end of the present volume. Under these circumstances all references to programmes have been omitted and only the results actually obtained during the year are discussed. A list of original and other papers published during the year is appended.

Wheat.—During the present year a large number of papers have been published on the improvement of the wheat crop. The large amount of work which has been done already throughout India on wheat is the direct result of the discussion which took place at the second meeting of the Board of Agriculture held at Pusa in 1906. At this meeting a scheme for the improvement of the wheat crop was adopted by the Board. Steps were also taken for the preparation of a monograph on the crop to include a botanical survey of the varieties grown, a digest of the scattered information on wheat both in India and other countries together with detailed suggestions for future work. The book, which is entitled *Wheat in India,*

has appeared during the year. The first section deals with the production of wheat in India and also contains a short summary of the various wheat experiments which have been carried out at the experimental farms. The materials from which this section was derived were found to be very widely scattered and quite inaccessible to the student of Indian Agriculture. The second section of the book deals with the diseases of wheat, while the last portion, which is, in the main, original, deals which the improvement of Indian wheat. This section includes a botanical survey of the wheats of India and the recent work which has been done at Pusa on the milling and baking qualities of the wheats of this country. It is hoped that the book will serve as a work of reference to all interested in Indian wheat.

A considerable amount of progress has been made during the year at Pusa on the testing of Indian wheats both in the field and also in the mill and bake-house. The results have been published in Pusa Bulletin No. 17 during the present year. The milling and baking tests have been carried out in England by Mr. A. E. Humphries, a former President of the Incorporated National Association of British and Irish Millers and a well-known authority on these questions; while the analytical work has been conducted, as formerly, by Dr. J. W. Leather, Imperial Agricultural Chemist at Pusa. The views published in a former paper (Pusa Bulletin No. 14) on this subject aroused a considerable amount of attention in India. It was stated in the earlier paper that some of the hard red wheats of the Punjab and especially those liked by the people, gave much better results in the mill and bake-house than the soft white kinds of the type of Mozaffernagar, the cultivation of which has been so consistently advocated since the publication of Messrs. MacDougalls' milling report in 1882. In addition, a Pusa selection (No. 6), originally grown from one plant, proved to be a much better milling wheat, much higher in nitrogen and with greater flour strength than anything previously grown in India. The recommendations in the paper in question were referred by the Director of Agriculture of the Punjab to the President of the Incorporated National Association of British and Irish Millers and the whole subject was considered by the Council of the Association. The result was that the recommendations in Pusa Bulletin No. 14, which were based on Mr. Humphries' report of 1908, were unanimously endorsed by the Council of the most important Milling Association of the Empire, while two of the largest Home millers (Messrs. Nicholls and Rank) proposed and seconded the motion that was adopted. The results obtained and published during the present year in Pusa Bulletin No. 17 more than bear out the

promise of the work of the previous year. Several of the Pusa selections proved superior to Pusa 6 and behaved in the mill and bake-house like Canadian and American Spring wheats which are the most valuable wheats imported into England. These results prove that the idea previously held that India can only grow weak wheats with moderate milling qualities, must be revised and that there is every hope that wheats with great strength and high milling qualities can be successfully produced on the alluvial plains of India. The Pusa selections referred to above, together with some of the new hybrids produced from them are now being tested on a field scale in several localities and the best of these will be distributed to the cultivators.

Progress has also been made in another direction with Indian wheat, namely, on the influence of the environment on the milling and baking qualities. This investigation is being conducted in collaboration with the Economic Botanist to the Government of the United Provinces, and the results obtained up to the present have been published as a memoir of the Agricultural Department. The same wheat, Mozaffernagar, has been grown at a large number of stations in the Indo-Gangetic plain under widely different circumstances as regards soil and irrigation. The samples were analysed, ground into flour and made into bread. The nitrogen percentage of the Cawnpore sample was over 80 per cent. higher than that grown at Aligarh, there were great differences in consistency, while Mr. Humphries considered there was a difference in money value of several shillings per quarter between the best and the worst. There was practically no difference in quality between the Pusa sample grown without irrigation and the Cawnpore sample grown under canal irrigation. This point is of considerable interest as indicating that canal irrigation does not necessarily injuriously affect the milling qualities of wheat. This supposition is further confirmed by the behaviour in milling of five Punjab wheats grown with canal water at Cawnpore. The samples were exceedingly uniform in texture and behaved very well in the mill. Evans has published a short paper on a somewhat related subject in connection with wheats of the Central Provinces where it has been found that excessive irrigation (nine waterings) softens the local wheats, especially the macaroni wheats. These results confirm the earlier work of Le Clerc in the United States on the same subject.

New ground has been broken in another direction with regard to the yield and quality of Indian wheat. It has been repeatedly observed at Pusa that hot weather cultivation of wheat lands leads to a greatly

enhanced yield in the following *rabi* season and, moreover, that the milling qualities of the grain are also improved. The Pusa results have been repeated at Cawnpore and it is believed that they will be of very general application throughout the Indo-Gangetic plain. The investigations recently carried out by Russell and his colleagues at Rothamstead appear to afford an adequate explanation of the increased fertility of the Indian alluvium after it has been exposed to the sun and air during the hot weather. Russell has found that sterilising the soil by heating or by poisons kills off the phagocytes which live on bacteria and also other soil organisms inimical to bacteria. At the same time the soil bacteria are killed off, but the spores remain which germinate and rapidly multiply when the soil is moistened. The new bacterial cultures increase at an enormous rate and the resulting nitrogenous food material becomes so great that plant growth is stimulated. It is not unlikely that the intense heat and dryness of the Indian hot weather has a similar sterilising effect on the soil organisms and that the luxuriant growth which follows weathering is the result of an alteration in the soil flora. Attention has been drawn to this subject in *Nature* and the field trials already completed at Pusa support the views put forward. It is satisfactory to note that the results obtained on this subject at Pusa and Cawnpore, have attracted a good deal of attention in the various Provincial Agricultural Departments and further evidence on the subject will no doubt be available shortly. It is believed that by a combination of hot weather cultivation and occasional green manuring the crop production of the Indo-Gangetic alluvium can be vastly increased and that no more promising field for future work has so far been discovered in the history of agricultural improvement in India.

During the year a large amount of culture work dealing with the extent of natural cross-fertilization in wheat in India has been completed at Pusa and the results are now in the press. It has been found that, under canal irrigation in the Punjab, cross-fertilization in wheat is exceedingly frequent and 226 cases were proved in one year at Lyallpur. Natural crossing in wheat at Pusa occurs rarely and the difference between the behaviour of the same crop in the Chenab Colony and in Bihar is entirely due to the difference in the water supply of the crop in the two cases. At Lyallpur, where wheat is grown entirely under canal irrigation, the crop is watered at least twice after sowing, the last watering taking place after the plants are in ear. Often before this last irrigation the supply of water in the soil is so small that the plants wilt during the hottest part of the day, the glumes open and the stigmas are exposed to the air. Under such

circumstances natural crossing is easy and frequent. At Pusa where wheat is grown without irrigation on high moisture retaining loams, the supply of water is more constant and this wilting does not take place. Consequently natural crossing is rare. These results are interesting from the scientific aspect in showing that environment may modify the usual pollination mechanism in a crop. On the economic side they show that wheat breeding will be difficult at Lyallpur and that the growth of pure wheat seed for distribution to the people is not such an easy matter as in other tracts of India.

The trade aspect of the wheat investigations in India referred to above has been emphasised by the Director of Agriculture of the Punjab and also by Sir James Wilson, K.C.S.I., formerly Financial Commissioner of that Province.

Cotton.—No important papers have been published on this crop during the year under review. At Lyallpur, Milne has described the cotton selection experiments in progress in the Punjab and in Madras, Wood has given an account of similar work at the Nandyal Experiment Station. In both cases the results are published in the Farm reports for 1908-1909.

Fibres.—Several papers on fibres have appeared during the year. Finlow, in the *Agricultural Journal of India*, discusses the work done on the "heart damage" of baled jute by Messrs. Cross & Bevan in London and outlines further work on the subject which it is desirable should be conducted in India.

Two papers on *San* (*Crotalaria juncea L.*) have been published. In the *Agricultural Ledger*, No. 7 of 1908-1909, an account is given of *san* hemp in the Pabna District where two kinds are grown, one called *chotna* for green manuring and the other *boran* for fibre. A short paper has been published in the Botanical Memoirs of the Agricultural Department on two distinct varieties of this crop. A tall, unbranched, fibre yielding kind is grown in the Central Provinces, while the local Bihar variety is much dwarfer, more branched and less suitable for fibre. Other different varieties have since been isolated. An improvement in the use of this crop for green manuring has also been worked out at Pusa. It has been found that the best results are obtained when the crop is sown early in a well cultivated soil and when the green crop is ploughed in during the first week in July. This enables the *san* to decompose thoroughly and to be incorporated into the soil before the end of the monsoon. In addition, there is ample time for the soil to take up a sufficiency of the monsoon rains for the succeeding *rabi* crop.

Fruit.—Continued attention is being paid to fruit culture in India, but only one paper on the subject has appeared during the year, namely, the second report on the Pusa fruit experiments. This paper deals with the results which have been obtained and a detailed account of peach growing in Bihar and of the fruit packing experiments at Pusa is given. Perhaps the most interesting result is that of the tillage experiment where the deleterious effect of grassing down has been even greater than that found in the case of apples at Woburn in England and since repeated at many other places.

Plant Breeding.—Two papers of general interest on this subject were completed during the year one of which has already appeared. Woodhouse has published a short sketch dealing with the possibilities of improving the crops of Bengal by the method of pure line culture. For some years the occurrence of natural cross-fertilization in the Indian crops has been studied at Pusa and the results obtained up to the present year are dealt with in a paper in the press. The experiments with wheat are referred to above under that crop. Other crops dealt with are tobacco, peas, *khesari* (*Lathyrus sativus*, L.), beans, tobacco, *Hibiscus cannabinus* L. and *H. sabdariffa* L., cotton, linseed, the cruciferous oil-seeds, opium poppy, safflower, castor, *Sesamum indicum* and *S. niger*. The results have an important bearing on the choice of the methods of plant improvement, on the testing of varieties, on the introduction of exotics and also on seed distribution.

Tobacco.—Two papers on the work done at Pusa on this subject have been published. Both have appeared in the Botanical memoirs of the Agricultural Department. The first relates to the types of *Nicotiana rustica* and to the occurrence of natural crossing in this crop. The second deals in detail with the botany of the Indian types of *Nicotiana tabacum*. These papers are introductory to the further study of this crop and to the tobacco breeding experiments in progress at Pusa which are now in the second generation. It is hoped to publish the first results on the inheritance of characters in this crop during the present year.

Miscellaneous.—Burkill has published an interesing paper on the plants used in the preparation of Indian pens in the *Agricultural Ledger* and this author has also contributed two papers of economic interest to the *Journal of the Asiatic Society of Bengal*. One refers to some of the oil grasses in the Central Provinces and Berar and the other to the drug known as *Coptis*. Hooper in the same Journal has given an account of tamarisk manna.

List of papers on Economic Botany published during the year ending June 30th, 1910.

BURKILL, I. H. . . Indian pens, their history, classification, materials used and methods of manufacture. (*Agr. Ledger, No. 6, 1908-09.*)

BURKILL, I. H. . . On Coptis (*Jour. Asiat. Soc., Bengal, v, 1909, 73*).

BURKILL, I. H. . . First notes on *Cymbopogon Martini* (*Jour. Asiat. Soc., Bengal, v, 1909, 89*).

BURNS, W. . . . Annual Report of the Ganeshkhind Botanical Station, 1908-09. Government Central Press, Bombay.

BURNS, W. . . . Annual Report of the Bassein Botanical Gardens, 1908-09. Government Central Press, Bombay.

CLOUSTON, D. . . A promising weed. (*Agr. Jour. of India, v, 1910, 165.*)

EVANS, G. . . . Annual variations in the character of Central Provinces wheats. (*Bull. No. 3, Depart. Agric., Cent. Prov., 1909.*)

FINLOW, R. S. . . Heart Damage of Baled Jute. (*Agr. Jour. of India, iv, 1909, 274.*)

HENDERSON, G. S. . Report on Kahno wheat from Sind. (*Agr. Jour. of India, v, 1910, 78.*)

HOOPER, D. . . . Tamarisk manna. (*Jour. Asiat. Soc., Bengal, v, 1909, 31.*)

HOOPER, D. . . . The composition of Indian rice. (*Agr. Ledger, No. 5, 1908-09.*)

HOWARD, A. . . . Second Report on the Pusa Fruit Experiments. (*Bull. 16, Agr. Res. Inst., Pusa, 1909.*)

HOWARD, A. & HOWARD, G. L. C. Wheat in India. Calcutta, 1910.

HOWARD, A. & HOWARD, G. L. C. The Fertilising influence of sunlight. (*Nature, Feb. 17th, 1910.*)

HOWARD, A. & HOWARD, G. L. C. The milling and baking qualities of Indian wheats. No. 2. Some new Pusa selections tested in 1909. (*Bull. 17, Agr. Res. Inst., Pusa, 1909.*)

HOWARD, A. & HOWARD, G. L. C. Studies in Indian Tobaccos. No. 1. The types of *Nicotiana rustica* L. (*Mem. Dept. of Agr., India* (*Botanical Series*), *iii, No. 1, 1910.*)

HOWARD, A. & HOWARD, G. L. C. Studies in Indian Tobaccos. No. 2. The types of *Nicotiana tabacum* L. (*Mem. Dept. of Agr., India* (*Botanical Series*), *iii, No. 2, 1910.*)

HOWARD, A. & HOWARD, G. L. C. Studies in Indian Fibre Plants. No. 1. On two varieties of *San, Crotalaria juncea* L. (*Mem. Dept. of Agr., India* (*Botanical Series*), *iii, No. 3, 1910.*)

HOWARD, A.; LEAKE, H. M. & HOWARD, G. L. C. The influence of the environment on the milling and baking qualities of wheat in India. No. 1. The results of 1907-08 and 1908-09. (*Mem. Dept. Agr., India, (Botanical Series), iii, No. 4, 1910.*)

KULKARNI, L. B. . . The drugs of Sirsi and Kappat Hills. (*Jour. Bombay Nat. Hist. Soc., 1909, 574.*)

LONSDALE, J. M. . . Improvements in paddy cultivation on the home farm at Sivagiri, Tinnevelly District, (*Bull. 61, Madras, Agr. Dept.*)

MILNE, D. . . . In *Annual Report of the Lyallpur Experiment Station, 1908-09.*

PAL, UMA CHARAN . San Hemp in the Pabna District. (*Agr. Ledger, No. 7, 1908-09.*)

PATWARDHAN, G. B. . Lucerne dodder. (*Agr. Jour. of India, iv, 1909, 357.*)

RENOUF, W. C. . . The cultivation of "stronger" and more valuable wheats for export from the Punjab. (*Bull. 1, Dept. of Agr., Punjab, 1910.*)

SAWYER, A. M. . . The fatty oil of *Terminalia belerica* Roxb. (*Capital, July 22nd, 1909.*)

SAWYER, A. M. . . Talipot Sugar. (*Capital, 16th Dec., 1909.*)

SAWYER, A. M. . . The Soy bean. (*Capital, 10th March, 1910.*)

THOMPSTONE, E. . . Potatoes in Upper Burma. (*Agr. Jour. of India, v, 1910, 85.*)

THOMPSTONE, E. . . Lucerne or alfalfa cultivation. (*Agr. Jour. of India, iv, 1909, 319*).

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WOODHOUSE, E. J. . The possibilities of improving the crops of Bengal. (*Quarterly Jour. Dept. Agr., Bengal, iii, 1910, 236*).

MYCOLOGY.

BY

E. J. BUTLER, M.B., F.L.S.,

Imperial Mycologist.

Mr. MacRae, Officiating Imperial Mycologist, investigated a severe outbreak of blister-blight of tea in Darjeeling District. The disease has been known for many years, but was confined to North-East Assam, where it occasionally caused serious loss. The climatic conditions of Darjeeling appear to be more favourable to the parasite, and it spread with great rapidity after its first introduction in 1908. The life-history of the fungus (*Exobasidium vexans*) which causes it was fully studied by Mr. MacRae and experiments carried out to ascertain the best methods of checking it. The preliminary results were published by the Darjeeling Planters' Association in 1909, and fuller accounts have appeared in the Agricultural Journal of India, and as a Bulletin of the Pusa Institute in 1910.

The campaign against bud-rot of Palms in Madras Presidency was continued. Extension in the Godavari District has been checked but has progressed in Kistna, where the operations were started late. An account of the disease and of the results of the efforts made to stamp it out, was written by the Imperial Mycologist, and has appeared since the close of the period covered by this report

A serious disease of Areca palms, known locally as *Koleroga*, was investigated by Dr. L. Coleman, Mycologist and Entomologist to the Mysore Government. Spraying experiments carried out in 1909, demonstrated the

possibility of saving a great portion of the nuts at a low cost. With the exception of spraying for potato-blight which is practised to a limited extent in the Khasi Hills, this is probably the first successful application of this method of check'ng fungus diseases made in India on native crops. A full account of the disease and of the remedial measures adopted has since been published as a Bulletin of the Mysore Department of Agriculture.

The results of several years' investigation of the wilt disease of *tur* (pigeon-pea) were published by the writer early in the year. Incidentally it was shown that the fungus *Neocosmospora vasinfecta*, to which many similar diseases have been attributed is, at least in India, a harmless soil saprophyte.

Mr. MacRae visited Rangpur, Eastern Bengal, twice in connection with an enquiry into the cause and treatment of ginger-rot, a disease which the writer had found also to be prevalent in Gujarat. The fungus (*Pythium gracile*) which was noted as the probable cause of the disease in Gujarat was also found in the diseased plants at Rangpur. Attempts to cultivate it failed, so that absolute proof of its parasitism has not been obtained. An account of the disease with a description of the methods of treatment which have given successful results on the Burirhat Farm, is in the press.

Experiments in spraying potatoes with Bordeaux mixture as a protection against potato-blight were continued at the Upper Shillong Agricultural Station, and the results are given in the Annual Report of the Agricultural Stations in Eastern Bengal and Assam for 1908-09. The profit resulting from spraying was less than in previous years, but still amply justifies the practice. Demonstrations were carried out on an extensive scale on cultivators' holdings in the Khasi Hills with very satisfactory results, and a separate report on them is promised in the near future.

Mr. Burns, Economic Botanist, Bombay, is continuing his work on wheat rust at several of the Bombay stations, particularly with a view to determining the conditions by which the disease is influenced. Some notes on the subject are given in the Report of the Ganeshkhind Botanical Station for 1908-09 and a fuller account has been submitted for publication. Experiments in treating jowar seed to prevent smut were made at the Dharwar Agricultural Station. Steeping in 2 per cent. copper sulphate for 10 minutes was found to prevent the disease entirely. Attempts to obtain a wilt-resisting variety of *tur* are being made at Kirkee and Dharwar.

Mr. Clouston, Deputy Director of Agriculture, Southern Circle, Central Provinces, has continued to test cottons, with regard to their comparative

susceptibility to wilt, at Akola. *Buri* cotton has proved immune to this disease so far and is being introduced on wilt-affected lands. The use of copper sulphate as a steep for jowar seed was demonstrated widely in the Central Provinces where smut causes great losses. The practice is said to be extending amongst the cultivators. Mr. Evans, Deputy Director of Agriculture, Northern Circle, Central Provinces, is endeavouring by hybridisation and selection to obtain a rust-resistant wheat at Hoshangabad and is also trying to get a wilt-resisting *tur*.

At the Samalkota Station in Madras the work of resuscitating sugarcane cultivation in the Godavari Delta where it was dying out from the ravages of red-rot, was continued. The success obtained so far has been considerable. In the Report of the Station for 1908-09 Mr. R. C. Wood, Deputy Director of Agriculture, Northern Circle, Madras, summarises the practical results already obtained, but calls attention to a disheartening outbreak of disease on the Farm in the previous year. It has since been ascertained by the writer and Mr. A. Hafiz Khan that this was probably not red-rot, but a new root disease which is under study.

Mr. MacRae visited the Wynaad in November 1909, in company with Mr. Anstead, Planting Expert to the South Indian Planters' Association, to make further enquiries into the pepper-vine disease of Malabar. Reports on the tour are given in the Planters' Chronicle, Vol. IV, No. 12, and a scheme of experimental measures for its control, drawn up jointly by the two officers, in Vol. V, No. 2 of the same journal.

Mr. Burns has contributed short notes on diseases of mango trees to the Poona Agricultural College Magazine.

The cocoanut-palm disease in Travancore continues to occupy the attention of the Agricultural Department of that State. In the Annual Report of the Department for 1908-09, Mr. N. K. Pillai outlines the scheme of experiments in the treatment of the disease which he has started, and gives further notes on the area affected and prospects of successful treatment.

Numerous short notes on fungus diseases of rubber, tea, coffee, pepper and other plants have been contributed to the Planters' Chronicle by Mr. Anstead.

The operations carried out in Coorg to limit the spread of spike disease of Sandal are reviewed by Mr. C. McCarthy, Deputy Conservator of Forests, in the Progress Report on Forest Administration in Coorg for 1908-09. Though the extension of the disease into the unaffected northern portion of the province has been checked, there is no appreciable lessening of its severity within the affected area.

An account of a suspected parasite of several important forest trees and palms was contributed by the writer to the Indian Forester. The fungus (*Fomes lucidus*) is a common tropical and sub-tropical species, but has hitherto been generally supposed to be harmless.

An important contribution to the little studied bacterial diseases of plants was published by Dr. Coleman in the Mysore Agricultural Bulletins. The disease is one which affects potatoes throughout Peninsular India and is known as "ring" or "*bangadi*" disease. The bacterium which causes it was isolated and successful inoculations obtained not only on potatoes but also on brinjals and tomatoes. Suggestions for checking its ravages are given.

List of Publications.

ANSTEAD, R. . . Numerous notes on fungus diseases of rubber, tea, coffee, pepper, etc. in *Planters' Chronicle, iv, v, 1909-10.*

BURNS, W. . . Notes on wheat rust in *Ann. Rep. of the Ganesh-khind Bot. Stat. for 1908-09, Bombay, 1909.*

BURNS, W. . . "A note on red rust of the Mango tree" and "Observations on diseases of the Mango tree" (*Poona Agri. Coll. Mag., i, Nos. 1 and 2, 1909-10.*)

BUTLER, E. J. . . *Fomes lucidus* (Leys) Fr., a suspected parasite. (*Ind. For., xxxvi, Sept. 1909.*)

BUTLER, E. J. . . The wilt disease of pigeon-pea and the parasitism of *Neocosmospora vasinfecta.* Smith. (*Mem. Dept. of Agric. in India, Bot. Ser., ii, No. 9, 1910.*)

CLOUSTON, D. . . in *Report on the Agricultural Stations in the Central Provinces for the year 1908-09, Nagpur, 1909.*

COLEMAN, L. C. . The Ring disease of Potatoes (*Bull. No. 1, Mycol. Ser., Dept. of Agric., Mysore State, 1909.*)

EVANS, G. . . in *Report on the Agricultural Stations in the Central Provinces for the year 1908-09, Nagpur, 1909.*

MCCARTHY, C. D.'A. Spike disease in Sandal (*Progress Report on Forest Administration in Coorg for 1908-09, Bangalore, 1910.*)

MACRAE, W. . . The Outbreak of Blister-blight on tea in the Darjeeling District in 1908-1909 (*Ag. Jour. Ind., v, 126, 1910.*)

MacRae, W. . . Report on the Outbreak of Blister-blight on tea in the Darjeeling District in 1908-09 (*Bull. A. R. I. Pusa, No. 18, 1910.*)

MacRae, W. . . Pepper-Vine disease (*Planters' Chronicle, iv, 352 and v, 13, 1909-10.*)

Main, T. F. . . in *Annual Report on the Experimental work of the Dharwar Agricultural Station for 1908-09. Bombay, 1909.*

Pillai, N. K. . Cocoanut palm disease in *Annual Report of the Department of Agriculture, Travancore, for the year 1908-09, Trivandrum, 1909.*

Wood, R. C. . . in *Scientific Report of the Samalkota Agricultural Station for 1908-09, Madras, 1909.*

FOREST BOTANY.

BY

C. M. McCRIE, F.C.H.,

Acting Imperial Forest Botanist.

I.—Work done at the Imperial Forest Research Institute.

Educational Work of Forest Botanist.

1. From July to October the Botanist gave the usual course of botanical instruction to students of the 3rd year, and in March 1910 he conducted the final examinations in Botany of the Ranger class.

Facilities for Research Work. (a) Herbarium and Collections.

2. The re-arrangement of the Saharanpur herbarium (now located at Dehra Dun) and its amalgamation with the herbarium of the Research Institute and College were continued during the year under report, and had been nearly completed by its close. Additions to the herbarium during the year numbered 512 sheets, including a valuable set of 174 duplicates received from Calcutta. A set of duplicates from Dehra Dun was sent to Calcutta in exchange for those received, and it is hoped that this system of exchange may be extended with other herbaria

in India. During the year 35 specimens were identified and named for Forest officers in all parts of India and Burma, and 6 for independent enquirers.

A start was made with a collection of specimens in the College to show type trees and plants of the main natural orders and sub-divisions of the vegetable kingdom. These are to be exhibited in glazed cases for convenience of reference by students and others, and are intended to comprise—

(i) a complete botanical specimen of the species,
(ii) a photograph of the tree or plant,
(iii) specimens of the fruit, seed, and bark.

By the close of the year specimens of 151 species had been collected in readiness for exhibit as soon as glazed cases are ready to receive them. A reference collection of seeds has also been started, in which 60 species are now represented.

(b) Botanical Library.

Two hundred and thirteen volumes were added to the Library during the year. A revised system of classification of the books was sanctioned, and a complete catalogue was drawn up in accordance therewith.

(c) Accommodation.

A botanical laboratory and a potting shed in the experimental garden were built during the year. With these additions the accommodation provided is sufficient for present purposes.

Research Work of Forest Botanist.

3. The following subjects were included in the programme of research for the year :—

(*a*) Study of the coppicing of Teak, and of its effect on the normal health and development of the tree.
(*b*) Study of forest grasses, with special reference to the effects produced by repeated firing.
(*c*) Study of the various species or forms of Grewia of economic importance.
(*d*) Study of Teak reproduction.
(*e*) Study of Sal reproduction.

As regards the first subject, the investigations begun last year on the effect of coppicing on the normal health and development of Teak were continued, but are not yet complete. A preliminary note on the best season for coppicing Teak was published during the year, giving the results of experiments conducted in the Jubbulpore Division of the Central Provinces.

These experiments indicate that the best months for coppicing this species are March and September, or, to put it more generally, that the *worst* period for such fellings is from the time when vegetative activity commences up to, and for a short time after, the full development of the foliage, while the *best* season is immediately before and after this period.

The results of the enquiry regarding forest grasses, commenced last year, were worked up during the year under report, and were sent to press for publication in the form of a Memoir. These results indicate that forest grass lands should as far as possible be classified as follows :—

(i) those which are required for grazing and for the production of fodder;

(ii) those which are not required for fodder production and which it is advisable to afforest.

The enquiry has shewn that the production of trees and that of grass are two distinct and more or less incompatible objects which require distinct methods of treatment.

As regards fodder supply, the work has shewn that where hygrophilous or coarse mesophilous grasses are dominant, early firing is as a rule decidedly beneficial, as it :—

(i) increases the supply of palatable fodder from these species at a time when fodder is scarce, and

(ii) tends to replace these coarse species by less vigorous and generally more valuable fodder grasses, either by direct injury to the coarser plants themselves, or by drying up the soil and thus rendering it less fit for the coarser species.

In those grass lands where valuable fodder grasses are already dominant, firing may tend to favour the spread of the less desirable species, and is not advisable.

As to afforestation, the enquiry has shewn that it is advisable to classify the local grass lands into :—

(i) those in which the vigorous growth of most woody plants is made impossible by frost, the latter being the factor of dominant importance;

(ii) those in which damage by frost is seldom or never severe.

In lands of the first class, only the most frost-hardy species such as *Acacia Catechu* and *Zizyphus Jujuba* can be introduced with any hope of success. In some cases it is possible that radiation might be decreased and the effects of frost diminished by (1) clearing lines through the surrounding

forest, and thus stimulating the circulation of air, or by (2) irrigating the soil and keeping it moist, which would increase the quantity of water vapour in the air.

As regards grass lands of the second class (*i.e.*, those not subject to severe frost) the investigations have indicated that, as a general rule, the species of grass dominant in each locality is an accurate indication of the prevailing conditions of soil and moisture, and thus points clearly to the tree species which can be introduced with the best prospect of success. Thus where *Saccharum ciliare* is dominant, the locality is generally suitable for dry miscellaneous forest species; where *Saccharum Narenga* prevails, the locality is usually suitable for Sal, and where *Erianthus Ravennæ* is dominant, moist miscellaneous forest species are indicated.

The study of the classification and description of the important tree species of *Grewia* was continued during the year under report, but could not be completed owing to the non-receipt of certain specimens from Baluchistan and the Shan States. This enquiry will be completed and the results published next year.

Observations were started in the experimental garden at Dehra Dun with the object of discovering the factors primarily responsible for the dying back of Sal and Teak seedlings. These observations are not yet complete, and require to be checked with the results of control experiments conducted in the forests. But so far as they go they appear to indicate that, under the local conditions of soil and climate, dying back is not a natural and inevitable incident in the life-history of the seedling, but is brought about by an insufficient supply of available moisture in the soil.

No touring could be done by the Botanist during the year. Mr. Hole was fully engaged at Head-quarters in working up the information and specimens collected during previous tours until he went on leave in the end of April 1910.

II.—Work done elsewhere.

4. Forest officers in all parts of India and Burma helped the Botanist with specimens required for his research work. A considerable number of botanical specimens were also collected for the Reporter on Economic Products to the Government of India, for the forthcoming Exhibition at Allahabad, and for other purposes. Investigations into matters connected with Forest Botany are in progress in several provinces, but none of these are in a sufficiently advanced state to be recorded at present. Interesting and valuable notes have, however, been collected by several officers (notably

in the Kheri and Bahraich Divisions of the United Provinces) on such subjects as the germination and development of seedlings of forest species, the times at which local species shed their leaves and put out new foliage, and the seasons of their flowering and fruiting. Experiments undertaken in the Gonda Division are reported to have shewn that Sal coppice shoots are capable of yielding perfectly fertile seed.

Mr. A. E. Lowrie, I.F.S., is preparing an illustrated list of trees, shrubs, etc., found in the Southern Circle of the Central Provinces, and Mr. D. O. Witt, I.F.S., was engaged on an illustrated list of the common grasses of the Berar Circle, which is expected soon to be ready for the press. Rai Sahib Upendranath Kanjilal, Extra Deputy Conservator of Forests, has revised his "Flora of the School Circle," and an enlarged edition of this work is now in the press.

5. The following publications of the year may be mentioned as dealing more or less directly with Forest Botany:—

NAYADU, S. . . The distribution and cultivation of *Acacia arabica* in Berar. (*Ind. For., xxxv, No. 9*).

LUSHINGTON, A. W. . The Genus *Citrus*, by A. W. Lushington. (*Ind. For., xxxvi, Nos. 6 and 7.*)

HOLE, R. S. . . Note on best season for coppice fellings of Teak (*Tectona grandis*). (*Forest Pamphlet No. 16.*)

SYLVICULTURE.

BY

R. S. TROUP, F.C.H.,

Imperial Sylviculturist and Superintendent of Forest Working Plans.

Measurements in sample-plots.

Hitherto measurements in sample-plots in typical forest crops have been carried out entirely by local Forest officers, the results being recorded at the Forest Research Institute. These measurements are concerned only with girth increments, and take no account of the volume of material produced per acre under different conditions. In order to calculate the girth increment of trees, with a view to fixing a girth limit for exploitation purposes and for estimating the rotation of the crop, these measurements are no doubt useful: for forming a correct idea of the productive capacity of the locality, however, they are of little value, since the girth increment of individual trees depends largely on the density of stocking of the crop, and though the several trees of the crop may show a rapid growth in girth, the volume increment per acre may be comparatively small.

This being so, it follows that in order to estimate the productive capacity of a forest area, and in order to classify localities according to productivity, it is necessary to carry out periodic volume measurements in typical fully-stocked crops and also to test the effect of thinnings of different degrees on the volume increment of the crop as a whole. This work will be carried out by the Sylviculturist, who has already selected a number of typical areas in the *sál* forests of the Siwalik, Garhwal and Kheri Divisions of the United Provinces. Actual measurements will commence forthwith, and will be pushed on as rapidly as time and staff permit.

Developments in sylvicultural systems:—
(*a*) Sál (Shorea robusta).

2. The question of introducing more uniform methods of working in *sál* forests continued to receive attention during the year. A block of *sál* forest about 7½ square miles in extent at Thano near Dehra Dun has recently been taken up as an experimental ground for the application of the system of successive regeneration fellings, and the Sylviculturist was engaged during the year in compiling a working-plan

for the forest in question, with a view to introducing the system experimentally.

(*b*) Teak (Tectona grandis in Burma).

3. It is some years since attention was first called to the adverse effects of continued fire-protection in some of the moister types of Teak forest in Burma worked under the selection system, and more recently a change of system has been suggested in order to ensure the adequate reproduction of Teak by utilizing the respective benefits of burning and fire-protection. This idea was strongly urged by Mr Beadon-Bryant in an article entitled "Fire Conservancy in Burma" in the *Indian Forester* of December 1907.

During the past year the matter has been under further consideration and a "Memorandum regarding prescriptions for improvement fellings in Teak working-plans in Burma, and the introduction of a more uniform system of working" was drawn up; this memorandum is printed in the *Indian Forester* of October 1909, page 584. A subsequent and more detailed memorandum, written after consultation with the Inspector-General of Forests, was read and fully discussed, and approved of with certain modifications, at a Forest Conference held at Maymyo in June 1910, and it is hoped that the system finally adopted by the Conference will shortly be applied as a tentative measure is some typical forest tract. Briefly stated, the system consists in concentrating improvement fellings and subsidiary operations over definite blocks throughout a period of 25 years, this being considered long enough to ensure the adequate establishment of Teak reproduction : this having been effected, other blocks will be taken in hand, the whole forest area being thus regenerated during one rotation, by successive regeneration periods. Although the system will tend towards the eventual formation of even-aged crops, this will not be accomplished during the first rotation, since it was decided by the Conference to be inadvisable as a general rule to fell under-sized teak trees in the interests of the future crop, even in blocks under regeneration.

Causes and effects of drought on *Sal* forests of Oudh.

4. A portion of the past season was spent in investigating the causes and effects of the drought of 1907 and 1908 on the *sál* forest of Oudh, and with the assistance of the local Forest officers a number of borings down to water-level were made in affected and unaffected areas to ascertain the effect of the sub-soil on the degree of damage done. This investigation is not yet complete, but it will be continued during the coming season.

Statistical information on Burma Teak forests.

5. A note on some statistical and other information regarding the Teak forests of Burma was prepared during the year, and has gone to press. This note, compiled from all the Teak working-plans hitherto published in Burma and from the control forms showing the results of working, furnishes information regarding types of forest, rate of growth, density of stocking, yield and outturn, and other matters.

Germination of *Sal* seed.

6. Experiments are in progress in all the principal *sál*-bearing areas with a view to testing the germinative power of *sál* seed collected from trees of all sizes from the smallest to the largest, and from sound and unsound trees, respectively. Experiments of this kind can be carried out only in the neighbourhood of the forests concerned, because *sál* seed cannot be kept for more than a few days owing to its perishable nature : hence local Forest officers are giving their assistance in carrying out the necessary germinating tests. The results, when complete, should be of value in helping to elucidate problems concerned with the regeneration of *sál* forests.

Working-plans sanctioned during the year.

7. Three working-plans were sanctioned during the year, namely—

(1) **Working-plan for the Forests of the Nowgong Division, Eastern Bengal and Assam.**—By E. M. Coventry, I.F.S. The plan deals with an area of about 157 square miles, partly of *sál* and partly of miscellaneous forest. Working for 10 years is prescribed by improvement fellings, with the object of restoring the previously overworked and partially ruined *sál* forest to a better condition.

(2) **Revised working-plan for the Bori Range Forests, Hoshangabad Division, Central Provinces.**—By A. A. Dunbar-Brander, I.F.S. This plan deals with an area of some 42 square miles of forest in which Teak is the principal species ; the forest is one of the most important tracts of Teak in the Central Provinces, but was in former days much ruined by shifting cultivation. The plan prescribes improvement fellings including thinnings and the removal of over-mature trees, for a period of 10 years.

(3) **Working-plan for the Mawku Working Circle, Upper Chindwin Division, Upper Burma.**—By L. C. Davis, I.F.S.

The area concerned is some 309 square miles, of which 299 square miles are Teak-bearing. The system prescribed is the selection system with a rotation of 180 years and an exploitable girth of 7 feet. The possibility, based on enumerations extending over 24 per cent. of the Teak-bearing area, is estimated at 5,000 sound Teak trees per annum. Improvement fellings in the interests of Teak will be carried out as far as practicable. The period of the plan is 24 years.

List of Indian Publications, 1909-10.

BEST, HON'BLE J. W. . The effects of cattle-grazing in Bhandara Division, Central Provinces. (*Ind. For., xxxv, 610.*)

BEST, HON'BLE J. W. . The prevalence and utility of *Xylia dolabriformis* in the Central Provinces. (*Ind. For., xxxv, 677.*)

CACCIA, A. M. F. . Note dealing with the Progress made in Working-plans outside the Madras and Bombay Presidencies, up to the 31st December 1908, with special reference to the application of the various Sylvicultural Systems. (*Forest Pamphlet No. 9.*)

CACCIA, A. M. F. . Revised (Fourth) Edition of D'Arcy's "Preparation of Forest Working-plans in India."

COVENTRY, E. M. . Working-plan for the Nowgong Reserved Forests, Eastern Bengal and Assam.

DAVIS, L. C. . Working-plan for the Mawku Working Circle, Upper Chindwin Division, Upper Burma.

DUNBAR-BRANDER, A. A. Revised Working-plan for the Bori Range Forests in the Hoshangabad Forest Division, Central Provinces.

MCCRIE, C. M. . The Mixed Teak Forests of the Saugor Division, and their Treatment. (*Ind. For., xxxv, 553.*)

REBSCH, B. A. . The Bamboo (*Dendrocalamus strictus*) Forests of the Ganges Division, United Provinces. (*Ind. For., xxxvi, 202.*)

TROUP, R. S. . Memorandum regarding Prescriptions for Improvement Fellings in Teak Working-plans in Burma,

and the Introduction of a more Uniform System of Working. (*Ind. For., xxxv, 584.*)

TROUP, R. S. . . The Practical Determination of the Girth Increment of Trees, with Tables.

ECONOMIC FOREST PRODUCTS.

BY

R. S. PEARSON, F.L.S.,
Imperial Forest Economist.

1. **Economic Museum.**—The work of the year commenced with the re-arrangement of the Forest Economic Museum. The foundation of this Museum was laid by Sir Dietrich Brandis in 1881. It was consolidated and improved by Mr. Gamble during his tenure of the office of Deputy Director and afterwards Director of the Dehra Dun Forest School.

The Museum, as constituted by those officers, was partly of a Botanical, and partly of an Economic character. On the inauguration of the Forest Research Institute it was decided to form a Museum entirely of Economic Forest Products and to hand over all purely Botanical specimens to the Forest Herbarium.

Besides the Economic specimens available in the old Museum, a large number of specimens were obtained from the Franco-British Exhibition of 1908, and from the Nagpur Exhibition, while others were collected by Forest officers in India and Burma, and by the students of the College. In this way the total number of exhibits available amounted to 1,350.

The classification and arrangement of the Museum was completed during the rains, and a descriptive catalogue prepared which is now in the press.

2. **Educational Work.**—It was found possible to reduce the educational work formerly entrusted to the Imperial Forest Economist, thus giving him more leisure to carry out his programme of research work. A course of lectures in Utilization was delivered to the senior students during the rains term, while the 3rd year class was given work in laboratory. A course of Surveying and Engineering was also given to the latter students during September and October.

3. **The Match Industry.**—The enquiry into the Match Industry was completed in 1908-09, the results of which have been recorded by Mr. Troup in his recently published memoir on the subject.

The position of the industry in India is as yet not altogether satisfactory. From the enquiry made into this business it was found that want of expert help, as also of a sustained annual yield of suitable wood for match sticks and boxes are the greatest difficulties to be overcome.

4. **Antiseptic treatment of Timber.**—A considerable amount of attention was paid to the antiseptic treatment of timber during the year. The enquiry naturally falls under two heads. The first portion of the enquiry consisted in treating specimens of timber with a variety of antiseptics on a laboratory scale, by which the amount of absorption and mode of penetration of the various preservatives was studied and estimates made as to the cost of each process. The pieces so treated were afterwards placed in the ground and kept under observation. The second part of the enquiry consisted in making arrangements for treating five thousand railway sleepers of five different species of timber by the Powell process, which when ready are to be laid down on one of the main railway lines and kept under observation. It is hoped to gradually extend this enquiry by treating fairly large numbers of railway sleepers with other antiseptics, as the results of past trials and the present laboratory experiments indicate that this is desirable.

So far as the results obtained by treating timber according to the open tank have come to hand, it is evident that whatever preservative is used the harder Indian timbers will require a longer period of immersion in a fluid, heated to a higher temperature, than is necessary for most of the European timbers. Various antiseptics have been given a trial, amongst which may be mentioned *Arenarius Carbolineum, Jodelite, Atlas solution, Coal-tar, Pine-tar. Soligaum, Green-oil, Bellit* and a mixture of chloride of zinc and sodium-fluoride, while 147 specimens of various species treated by the Powell process have also been kept under observation. Up to the present nearly all these processes have given good results, even with the softest woods, on the other hand all the specimens have been laid down within the last two years, an insufficient period from which to draw conclusions. Time only can prove their respective merits, while the value of the various solutions must largely depend on how far they are retained by the timber after heavy rainfall or on exposure to excessive heat. Theoretically speaking those substances which have a low boiling point are unsuitable as antiseptics, while solutions

containing heavy oils with a high boiling point, such as are yielded by the distillation of tar more closely fulfil the necessary conditions for good preservatives.

5. **Utilization of oil seeds yielded by forest trees.**—This enquiry has been going on for several years. The most useful result obtained was, with the oil from the seed of *Schleichera trijuga*, which was stated by a large factory to be most suitable for soap-making. At first a slight difficulty was experienced by the presence of ammonia salts in the oil, which was, however, overcome without much trouble. It is now hoped that it will be possible to work this oil on economic lines in connection with the manufacture of soap. Attempts were made to place the seed of *Prunus eburnea, Mesua ferrea, Hydnocarpus Wightiana, Bombax malabaricum,* and *Diospyros montana*, on the market, in most cases with fair success.

6. **Wood and Bamboo Pulp.**—One of the most important subjects under investigation was in connection with the possibility of manufacturing wood and bamboo-pulp. A commencement was made by visiting three of the largest existing paper mills in India, and discussing the position of affairs with the Managers. Further, many of the likely bamboo areas on the West Coast of India were visited, with a view to the collection of data as to the possible outturn from any one locality, cost of extraction, labour supply and to fix on possible factory sites. In order to ascertain the percentage of pulp yielded by the various timbers and bamboos, arrangements were made to carry out laboratory tests with the raw materials, and also to have tests made on a large commercial scale with 100 tons of bamboos and twenty varieties of timber. It is proposed to complete this enquiry by visiting the forests of Burma and Arakan.

7. **Investigation into the physical properties and seasoning power of Timber.**—By the courtesy of the Principal of the Civil Engineering College, Sibpur, the writer was allowed to use the testing machine at that Institute and to carry out experiments as to the relative strength of plantation and natural grown Teak from Burma. The timber on which the experiments were carried out came from the Zigon Division of the Pegu Circle. The results obtained shewed that as regards transverse strength the natural grown Teak was slightly stronger than the plantation grown timber, while the reverse was the case when crushing and shearing stress came into play. On the other hand the differences shown by each set of tests were so trifling that for all practical purposes both classes of timber were found to be of equal value. The experiment further demonstrated that the percentage of moisture in the timber is a very important factor so that

unless the percentage of moisture in two sets of specimens is very approximately equal, no reliable deduction can be made as to their relative strength. Another set of experiments is being carried out as to the liability of timber to split while seasoning. It is a well-known axiom that by retarding the process of seasoning the liability of timber to split is reduced. Working on this assumption, a substance known on the market as "Ligno," which is a thick brown paste, was applied to the ends of the short butts of green timber with a view to retarding the process of seasoning. The logs selected for treatment were taken from species known to be liable to split while seasoning and were laid down about a year ago and kept under observation. Untreated butts, cut from the same stems, were kept together with the treated specimens, so as to allow of comparison one with another. So far the results have shown that in some cases the treatment has been most beneficial, while in all cases it has tended to stop splitting. The moisture tests carried out to ascertain the relative rates of seasoning, however, showed that the untreated pieces are in many cases practically seasoned, while the treated specimens still contain a high percentage of moisture. The final results as to the value of this substance will not be available until the treated pieces are completely seasoned.

8. **Minor Investigations.**—A great number of minor investigations were carried out during the year, chiefly at the instance of Indian firms. Certain timbers were tested as to their suitability for pencil-making, of which *Cupressus torulosa* proved excellent, while the timbers of *Podocarpus neriifolia, Cedrus Deodara, Wrightia tomentosa, Wrightia tinctoria* and *Pinus longifolia* were also considered suitable, especially that of the two first mentioned species.

Sonneratia apetala was passed as suitable for packing-cases; *Taxus baccata* for bows; *Gmelina arborea* for mallet-handles; *Pterospermum acerifolium, Podocarpus neriifolia* and *Gmelina arborea* were considered (provisionally) suitable for mathematical instruments, such as set squares. Walnut "burrs" sent from the Panjab to a European firm, were considered to be little inferior to Persian "burrs" for the purpose of cutting veneers; *Holoptelea integrifolia* proved excellent for handles and that of *Diospyros Kurzii* and *Diospyros Melanoxylon* as suitable for brush-backs; while the results of the trials to be made on timbers being tested for cotton-mill rollers, knife and razor handles, fruit crates, paving-blocks, tea-boxes, cricket-bats, tool-handles, etc., are as yet not available.

9. **Botanical and other specimens.**—A large number of wood and botanical specimens, samples of seed and minor forest products, were

collected by the Forest Department and supplied to the Reporter on Economic Products; the Imperial Institute, London; the Imperial Forest Research Institute, Dehra Dùn; the Agricultural Research Institute, Pusa; the Imperial Bacteriologist, Muktesar; the Madras Museum; the Deputy Commissioner, Mianwali; South Africa; Austria; the Chemical Examiners, Lahore; the Lahore Technical School; the Bureau of Science, Manila; Philippines; Professor Percy Groom of the Royal College of Science, South Kensington, London; and to a number of firms and private persons both in India and Europe. The officers of the Forest Department also took great pains to collect a large number of wood-specimens which were missing in the wood collection of the Forest Research Institute, thus helping to complete this already extensive collection of Indian timbers.

Publications.—The following is a list of some of the important publications and articles brought out during the year and which deal with subjects of economic interest :—

Fibre producing plants in India (*Ind. For. October 1909, 561-569.*)

RAIT, WILLIAM . . A note on new fibres for paper (*Ind. For. Jan.-Feb. 1910, 34-36.*)

SINDAL, R. W. . . Bamboo for paper-making.

TROUP, R. S. . . . Note on Burmese Leza wood (*Lagerstroemia tomentosa*). Forest Pamphlet No. 10, Economy Series, No. 3.

TROUP, R. S. . . . Note on Carallia wood (*Carallia integerrima*). Forest Pamphlet No. 11, Economy Series, No. 4.

TROUP, R. S. . . . Note on Petwun or Trincomali wood (*Berrya Ammonills*). Forest Pamphlet No. 12, Economy Series, No. 5.

TROUP, R. S. . . . Note on Burmese in wood (*Dipterocarpus tuberculatus*). Forest Pamphlet No. 13, Economy Series, No. 6.

TROUP, R. S. . . . Note on Burma Padauk (*Pterocarpus macrocarpus*). Forest Pamphlet No. 14, Economy Series, No. 7.

TROUP, R. S. . . . Note on the Fissibility of some Indian woods. Forest Record, Vol. II, Part II.

TROUP, R. S. . . . . Indian Forest Memoir, Vol. II, Economy Series, Part I. Note on the Prospects of the Match Industry in the Indian Empire, with particulars of proposed match factory sites and woods suitable for match manufacture.

INDIAN ZOOLOGY

with special reference to the work of the Indian Museum.

BY

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Superintendent of the Indian Museum.

I.—Work in the Indian Museum.

Since my last report was submitted, the scientific staff of the Natural History Section has been reorganized and augmented by the appointment of two additional Assistant Superintendents, Mr. S. W. Kemp, formerly a member of the scientific staff of the Irish Fishery Board, and Mr. F. H. Gravely, formerly Lecturer on Zoology in the University of Manchester. These changes should render it possible to augment the practical utility of the Museum in several directions, especially as a centre of instruction for higher studies in zoology and scientific questions connected with fisheries. Applications are now being received from students who have passed through the ordinary courses in biology and desire instruction in methods of zoological research, and two such students have already worked in the Museum under Mr. Gravely.

Mr. Kemp, who has been appointed Senior Assistant Superintendent, has as yet devoted the greater part of his time in this country to a study of the Indian Decapod and Stomatopod Crustacea considered from a systematic point of view. He has a lengthy report on the latter nearly completed and has already published a revision of the Indian species of the genus Gennadas. He has also undertaken on behalf of the Museum an inquiry as to the cause of the death of fish in certain tanks in the Murshidabad district of Bengal. With adequate funds at its disposal the Museum would now be able to increase its work in such directions to a very considerable extent.

Mr. Gravely has commenced an investigation into the structure, life history and taxonomy of certain groups of Arachnida and Myriapoda, and has published several preliminary papers on the subject in the "Records of the Indian Museum" and "Spolia Zeylanica."

The systematic study of the freshwater fish of India and the surrounding countries has been undertaken by Mr. B. L. Chaudhuri, Assistant Superintendent, who has prepared a report on a large collection obtained from Tirhut through the generous assistance of Mr. M. Mackenzie, Circle Officer, Hathwa Raj, Saran, and another on a collection from Lake Tali Fu in Yunnan made by Mr. J. Coggin Brown of the Geological Survey of India. Mr. Chaudhuri has also identified a considerable number of fish from different parts of India which feed on mosquito larvæ. At least one of the species is new to science.

Mr. E. Brunetti, whose fruitful work on Indian Diptera must shortly come to an end through lack of funds, has been engaged for some time on a volume on the *Tipulidæ*, *Mycetophilidæ*, *Psychodidæ* and several other smaller families of *Nemocera* for the official "Fauna of British India," the large additions recently made to our collection of Diptera by himself and others having made it possible to undertake this important work, which could not have been contemplated elsewhere than in Calcutta.

I have myself continued my work on the fauna of stagnant water and have completed the manuscript of a volume of the "Fauna" on the sponges, polyps and polyzoa of fresh water. It is gratifying that at any rate two volumes of this series, of which about a dozen other volumes are now being prepared in Europe and America, should be written in India by authors with access to fresh material and to the collections preserved in this country.

A healthy sign of progress in the zoological work of the Museum is the interest shown in the collections by members of the non-gazetted staff, to whom we are indebted for the gift of several valuable collections of insects and other animals made while they were on leave or holiday. The collections

have also been widely extended by the exchanges with European and American Museums. Commanding as the Indian Museum does the supply of Indian specimens of several of the more important and obscure groups of animals, it is not difficult to fill in many blanks in the collection by this method, although it is of course much less satisfactory than that of collecting the specimens ourselves.

It is satisfactory to report that several distinguished zoologists from abroad have made use of our laboratories during the year. I may mention in particular the names of Sir Charles Eliot, Vice-Chancellor of Sheffield University, who examined certain Nudibranch Molluscs, and Mr. C. William Beebe, Curator of Birds in the New York Zoological Gardens, who prepared a full list of the collection of pheasants and their allies.

II.—Work elsewhere in India.

Zoological work has this year by no means been confined in India to the Museum. Text books for the use of Indian students have been prepared in Calcutta by Captain R. E. Lloyd, I.M.S., Professor of Biology in the Calcutta Medical College, and in Bombay by Dr. A. Powell, Professor of Biology in the Grant College. The former work is the more elaborate of the two and lays great stress on theory, in which the author expresses the views of an influential school of English zoologists without neglecting the more practical side of instruction. Captain Lloyd has also published a paper on Indian rats (Records, Indian Museum V.) in which fresh evidence is adduced as regards variation in the common species. In Lahore Major J. Stephenson, I.M.S., Professor of Biology in the Government College, has continued his researches on aquatic worms, while in Madras Dr. J. R. Henderson, Professor of Biology in the Christian College and Officiating Superintendent of the Government Museum, and his assistant Mr. G. Matthai have written a memoir on the freshwater prawns of South India which will be shortly published in the "Records of the Indian Museum." In the same periodical a revision of the Indian genera of Anopheline mosquitoes by Major S. P. James, I.M.S., will be issued immediately. Major James has also described a new genus of mosquitoes from material belonging to the Museum in the new journal "Paludism", which is devoted to the study of Malaria.

The Bombay Natural History Society has issued in its "Journal" a number of valuable papers, many of which have been illustrated in a manner that no other private society in the East could undertake.

III.—Work on Indian Zoology in Europe and America.

Perhaps the most important work on general lines published abroad during the year is Dr. P. Sarasin's paper on the geographical distribution of the fauna of Ceylon, its interest being by no means confined to that island.

Lieutenant-Colonel A. W. Alcock, F.R.S., has continued in England the work he inaugurated in India, by writing an account of the Indian freshwater crabs (*Potamonidæ*), which has been published as fasciculus 2, part I of the Catalogue of Decapod Crustacea in the collection of the Indian Museum. He has in this fascicule proposed many new characters whereby the species, genera and sub-genera of the *Potamonidæ* may be distinguished from one another and has added considerably to our knowledge of the distribution of the freshwater fauna of the Oriental Region. Dr. R. Koehler of the University of Lyons has added a fresh part to the Catalogue of the Echinoderms of the Indian Museum to which he and his colleague Dr. Vaney had already contributed four parts. The fifth part consists of a description of the shallow-water starfishes and is illustrated by a number of plates in which a large proportion of the Indian species are figured in a very clear manner by reproductions of photographs.

Two volumes of the "Fauna of British India" have appeared under the editorship of the new Editor, Dr. A. E. Shipley, F.R.S., one on the earwigs by Dr. Malcolm Burr and one on certain families of Lamellicorn beetles by Mr. G. J. Arrow.

References to other work will be found in the following list of papers, etc., published during the year and having a direct reference to Indian zoology. The list has been compiled by Mr. B. L. Chaudhuri, Assistant Superintendent, Indian Museum.

List of papers and books having a special reference to Indian Zoology recently published.

Memoirs published in India.

GENERAL.

In the *Records of the Indian Museum*. Contributions to the fauna of Yunnan, Introduction, by J. Coggin Brown, B.Sc., F.G.S., Assistant Superintendent, Geological Survey of India, Vol. v, 1910, 193.

Independent works. *Report on the Marine Zoology of Okhamandal in Kattiawar*, Part I, by James Hornell, F.L.S., with Supplementary Reports on (1) a new species of Pinnoteres, (2) the Anomura of Okhamandal, (3)

Alcyonarians of Okhamandal, and (4) the Nudibranchs of Okhamandal. 1909.

Lessons on Practical Biology for Indian Students. By Arthur Powell, B.A., M.Ch., Professor of Biology, Grant College, Bombay, 1910.

Porifera (Sponges).

In the *Records of the Indian Museum.* Notes on Freshwater Sponges, No. XI, by Dr. N. Annandale, D.Sc., F.L.S., C.M.Z.S., Superintendent, Indian Museum. Vol. iii, 1909, 275.

Notes on Freshwater Sponges. No. XII. Description of a new species from Cape Comorin. By the same author. Vol. v, 1910, 31.

Sponges from Yunnan. By the same author. *Ibid.*, 197.

Cœlenterates.

In the *Records of the Indian Museum.* Branchiocerianthus imperator von der Küste von Oman und Baluchistan. By E. Stechow, München. Vol. iii, 1909, 296.

The Hydroids of the Indian Museum. No. 1. The Deep-sea Collection. By James Ritchie, M.A., B.Sc. Vol. v, 1910, 1.

Annelida.

In the *Records of the Indian Museum.* Studies on the aquatic Oligochæta of the Punjab. By Major J. Stephenson, M.B., D.Sc., I.M.S., Vol. v, 1910, 59.

Note on Polychæte worms. By the same author. *Ibid.*, 82.

Myriapoda.

In the *Records of the Indian Museum.* On a sub-species of Scutigerella unguiculata, Hansen, found in Calcutta. By F. H. Gravely, M.Sc., Assistant Superintendent, Indian Museum. Vol. v, 1910, 157.

The distribution of the Oriental Scolopendridæ. By the same author. *Ibid.*, 161.

Crustacea.

In the *Records of the Indian Museum.* Diagnoses of new species and varieties of freshwater crabs (Nos. 1 – 4). By Col. A. Alcock, F.R.S., Vol. iii, 1909, 243, 375.

Notes on Decapoda in the Indian Museum (The species of Gennadas). By Stanley Kemp, B.A., Assistant Superintendent, Indian Museum (with plates). Vol. v, 1910, 173.

Description of a Barnacle of the genus Scalpellum from Malaysia. By Dr. N. Annandale, D.Sc., F.L.S., C.M.Z S. Vol. iii, 1909, 267.

The rate of growth in two species of barnacles. By the same author. *Ibid.*, 295.

Description of a new species of Scalpellum from the Andaman Sea. By the same author. Vol. v, 1910, 115.

The Indian barnacles of the subgenus Smilium, with remarks on the classification of the genus Scalpellum. By the same author. *Ibid.*, 145.

Two barnacles of the genus Dichelaspis new to Indian seas. By the same author. *Ibid.*, 213.

Occasional Publications of the Indian Museum. Catalogue of the Indian Decapod Crustacea in the collection of the Indian Museum, Part I Brachyura. Fasc. 2. The Indian Freshwater Crabs—Potamonidæ. By Col. A. Alcock, C.I.E., F.R.S., M.B., LL.D. (1910).

INSECTS.

In the *Records of the Indian Museum.* Notes on Neuroptera in the collection of the Indian Museum. By James G. Needham. Vol. iii, 1909; 185.

New Indian Leptidæ and Bombylidæ, with a note on Comastes Os. Sac., V. Heterostylum, Macq. By E. Brunetti. *Ibid.*, 211.

Notes on the Trichoptera in the collection of the Indian Museum. By C. Betten. *Ibid.*, 231.

Descriptions of three new Cicindelinæ (Coleoptera) from Borneo. By Dr. Walther Horn, Berlin. *Ibid.*, 259.

The Hemipterous family Polyctenidæ. By Dr. P. Speiser. *Ibid.*, 271.

Field notes on Indian Insects. By Dr. N. Annandale, D.Sc., F.L.S., C.M.Z.S., Superintendent, Indian Museum. *Ibid.*, 293.

Description of a minute Hymenopterous insect from Calcutta. By the same author. *Ibid.*, 299.

The Insect Fauna of Tirhut. No. 1. By H. Maxwell-Lefroy, M.A., F.E.S., F.Z.S., Imperial Entomologist. *Ibid.*, 301.

New Oriental Sepsinæ. By E. Brunetti. *Ibid.*, 343.

Second Report on the collection of Culicidæ in the Indian Museum, with descriptions of new genera and species. By Fred. V. Theobald, M.A. Vol. iv, 1910, 1.

The Indian species of Papataci Fly (Phlebotomus). By Dr. N. Annandale, D.Sc., F.L.S., C.M.Z.S. *Ibid.*, 35.

Taxonomic values in Culicidæ. By E. Brunetti. *Ibid.*, 53.

Revision of the Oriental blood sucking Muscidæ (Stomoxinæ, Philaematomyia, Aust., and Pristirhynchomyia, gen. nov.). By the same author. *Ibid.*, 59.

A new genus of Psychodid Diptera from the Himalayas and Travancore. By Dr. N. Annandale, D.Sc., F.L.S., C.M.Z.S. Vol. v, 1910, 141.

Notes on the larvæ of Toxorhynchites immisericors. By C. A. Paiva, Assistant, Indian Museum, *Ibid.*, 187.

Cockroaches as predatory insects. By Dr. N. Annandale, D.Sc., F.L.S., C.M.Z.S., Superintendent, Indian Museum. *Ibid.*, 201.

Note on Ædeomyia squammipenna. By C. A. Paiva, Assistant, Indian Museum. *Ibid.*, 202.

Named specimens of Chrysomelidæ in the Indian Museum. By S. Maulik, Temporary Assistant, Indian Museum. *Ibid.*, 202.

In the *Memoirs of the Indian Museum*. Étude sur les Chironomides des Indes Orientales, avec description de quelques nouvelles espèces d'Égypte (Avec les planches viii—xi). Par J. J. Kieffer, Doct. Phil. Nat. Professeur à Bitsch. Vol. ii, No. 4, August 1910.

In the *Journal of the Bombay Natural History Society*. The butterflies (Rhopalocera) of the Nimar District, Central Provinces. By D. O. Witt, I.F.S., Vol. xix, 1909, 564.

Biological Notes on Oriental Hemiptera, No. 4. By J. C. Kershaw and G. W. Kirkaldy. *Ibid.*, 571.

Descriptions of Indian Micro-Lepidoptera. By E. Meyrick, B.A., F.R.S., F.Z.S. (X—Eucosmidæ). *Ibid.*, 582. (XI—Oecophoridæ). Vol. xx, 1910, 143. (XII—Gelechiadæ). *Ibid.*, 435.

The Common Butterflies of the plains of India (including those met with in hill stations of the Bombay Presidency). By T. R. Bell, I.F.S. (continued from p. 439 of Vol. xix), with plates. Sub-family—Nymphalinæ. *Ibid.*, Vol. xix, 635 and 846; *Ibid.*, Vol. xx, 1910, 279.

Descriptions of new genera and species of Indian Ichneumonidæ. By P. Cameron, *Ibid.*, 722.

The Adaptations of Aquatic Insects to their environments. By Gordon Dalgliesh. *Ibid.*, 732.

The early stages of the Hawk moth (Theretra palligosta). By C. E. P. Manson. *Ibid.*, 760.

The Moths of India (Supplementary paper to the volumes in *Fauna of British India* series IV, part I) By Sir George F. Hampson, Bart., F.Z.S., F.E.S. (with plates). *Ibid.*, Vol. xx, 1910, 83.

The Butterflies of Kumaun, parts I-II (with a map). By F. Hannyngton, I.C.S. *Ibid.*, 130 and 361.

A list of the Butterflies of the Palni Hills. By Captain W. H. Evans, R.E., *Ibid.*, 380.

The Natural History of Bombay Malaria. By C. A. Bentley, M.B., C.M. (Edin.) *Ibid.*, 392.

Additions and corrections to certain local Butterfly lists. By Captain W. H. Evans. *Ibid.*, 423.

Biological Notes on Aphnæus hypargyrus, with a plate. By Captain F. C. Fraser, M.D., I.M.S. *Ibid.*, 528.

In the *Journal and Proceedings of the Asiatic Society of Bengal.* Review of our knowledge of the Oriental Diptera. By E. Brunetti. Vol. vi, No. 3 (1910), 135. Exhibition of a collection of Indian Earwigs by Dr. N. Annandale, D.Sc., F.L.S., C.M.Z.S., *Ibid.*, Vol. vi, No. 6 (1910), cxx.

Secretion of Phromnia marginella, Olivier. By D. Hooper. *Ibid.*, Vol. v, No. 9 (1909), 363.

In *Paludism: Transactions of the Committee for the Study of Malaria in India.* Notes on Mosquitoes. By Major S. P. James, I.M.S., No.1 (July 1910), 33.

Arachnida.

In the *Records of the Indian Museum.* On some new or little known Mygalomorph spiders from the Oriental Region and Australasia. By Stanley Hirst. Vol. iii, 1909, 383.

Mollusca.

In the *Records of the Indian Museum.* Descriptions of two new shells from South India. By H. B. Preston, F.Z.S., Vol. iii, 1909, 277.

Descriptions of new shells in the collection of the Indian Museum from Burma, Siam and the Bay of Bengal. By H. B. Preston, F.Z.S. Vol. v, 1910, 33.

Descriptions of 5 new species of marine shells from the Bay of Bengal. By H. B. Preston, F.Z.S., *Ibid.*, 117.

Note on Slugs from the Eastern Himalayas. By Dr. N. Annandale, D.Sc., F.L.S., C.M.Z.S., Superintendent, Indian Museum, *Ibid.*, 214.

Polyzoa.

In the *Records of the Indian Museum.* Preliminary note on a new genus of Phylactolæmatous Polyzoa. By Dr. N. Annandale, D.Sc., F.L.S., C.M.Z.S., Superintendent, Indian Museum. Vol. iii, 1909, 279.

Large Colonies of Hislopia lacustris. By Major H. J. Walton, I.M.S., *Ibid.*, 295.

A new species of Fredericella from Indian Lakes. By Dr. N. Annandale, D.Sc., F.L.S., C.M.Z.S. *Ibid.*, 373.

Materials for a revision of the Phylactolæmatous Polyzoa of India. By the same author. Vol. v, 1910, 37.

Echinoderma.

In the *Records of the Indian Museum.* Description d'Ophiures nouvelles provenant des dernières campagnes de "l' Investigator" dans l'Océan Indien. Par R. Koehler, Professeur de Zoologie à l'Université de Lyon. Vol. v, 1910, 83.

Description d'Holothuries nouvelles appartenant an Musée Indien. Par R. Koehler, Professeur de Zoologie à, l'Universitè de Lyon, et C. Vaney, Maître de conferences à l'Université de Lyon. *Ibid.*, 89.

Occasional publications of the Indian Museum. An Account of the Shallow-water Asteroidea. By Rene Koehler, Professor of Zoology in the University of Lyon. (June 1910.)

Fishes.

In the *Records of the Indian Museum.* Notes on Indian Fresh-water Fish. By Dr. J. T. Jenkins, Ph.D., D.Sc. Vol. iii (1909), 286.

Descriptions of new species of Botia and Nemachilus. By B. L. Chaudhuri, B.A. (Cal.), B.Sc. (Edin.), Assistant Superintendent, Indian Museum. *Ibid.*, 339.

Notes on fish from India and Persia, with descriptions of new species. By J. T. Jenkins, Ph.D., D.Sc., Superintendent, Lancashire and Western Sea Fisheries. Vol. v, 123.

Description of a new species of Nemachilus. By B. L. Chaudhuri, B.A. (Cal.), B. Sc., (Edin.), Assistant Superintendent, Indian Museum. *Ibid.*, 183.

In the *Journal of the Bombay Natural History Society.* A preliminary list of the fishes of Tirhoot, Bengal. By Gordon Dalgliesh. Vol. xx, 1910, 428.

In the *Journal and Proceedings of the Asiatic Society of Bengal.* Exhibition of some fresh water Trygons. By Dr. N. Annandale, D.Sc., F.L.S., C.M.Z.S. New series, Vol. vi (1910), No. 7, cxxiv.

Description of a new species of Triacanthus. By B. L. Chaudhuri, B.A. (Cal.), B.Sc. (Edin.), Assistant Superintendent, Indian Museum. New series, Vol. vi, No. 9, 1910, 497.

In the *Spolia Zeylanica.* Observations on the nests, eggs and larvæ of Ophiocephalus striatus. By Dr. A. Willey. Vol. vi, part xxiii, December 1909, 108.

The occurrence of Solenostoma off the coast of Ceylon. By the same author. *Ibid.*, 102.

Amphibians.

In the *Records of the Indian Museum.* Notes on Indian Batrachia. By Dr. N. Annandale, D.Sc., F.L.S., C.M.Z.S., Superintendent, Indian Museum. Vol. iii, 1909, 282.

An undescribed Burmese frog allied to Rana tigrina. By the same author. Vol. v, 1910, 79.

Description of a South Indian frog allied to Rana corrugata of Ceylon. By the same author. *Ibid.*, 191.

Reptiles.

In the *Records of the Indian Museum.* Report on a small collection of lizards from Travancore. By Dr. N. Annandale, D.Sc., F.L.S., C.M.Z.S., Vol. iii, 1909, 253.

Major Wall on some forms of Dipsadomorphus. By the same author. *Ibid.*, 281.

Notes on the Darjiling skink (Lygosoma sikkimensis). By the same author. Vol. v, 1910, 201.

In the *Journal of the Bombay Natural History Society.* A popular treatise on the common Indian snakes. Part xi (with plate and map) (continued from p. 299 of Vol. xix, of 1909). By Major F. Wall, I.M.S., C.M.Z.S. Vol. xix, 555. Part xii, Dendrelaphis tristis and

pictus. Vol. xix, No. 4 (February 1910), 775, also Vol. xx, 1910, 65.

Notes on snakes collected in Upper Assam. By the same author. *Ibid.*, 608 and 825.

A new blind snake from the Western Himalayas (Typhlops mackinnoni). By the same author. *Ibid.*, 805.

Notes on snakes collected in the Jalpaiguri District. By the same author. *Ibid.*, 897.

A new snake from Assam. Oligodon erythrorhachis. By the same author. *Ibid.*, 923.

A collection of the Ophidia from the Chin Hills. By F. E. W. Venning, with notes from Major F. Wall, I.M.S., C.M.Z.S. Vol. xx, 1910, 331.

A new Tropidonotus from the Chin Hills. By Major F. Wall, I.M.S., C.M.Z.S. *Ibid.*, 345.

In the *Journal and Proceedings of the Asiatic Society of Bengal.* Medicinal Lizards. By David Hooper. Vol. vi, No. 6 (1910), 301.

Birds.

In the *Records of the Indian Museum.* Notes on the occurrence of Vulture monachus in Calcutta. By E. C. Stuart-Baker, F.Z.S., F.L.S. Vol. v, 1910, 81.

An Albino Owl. By Dr. N. Annandale, D.Sc., F L.S., C.M.Z.S. *Ibid.*, 81.

In the *Journal of the Bombay Natural History Society.* Notes on the birds of Chitral. By Captain G. A. Perreau, F.Z.S. Vol. xix (1909-1910), 901.

Seasonal change of Plumage of the Indian white-eye (Zosterops palpebrosa). By the same author. *Ibid.*, 983.

Common Myna (A. tristis) feeding young of Pied Myna (S. contra) and nesting habits of the common Pariah Kite (M. govinda) and Brahminy Kite (H. indus). By Charles M. Inglis. *Ibid.*, 985.

Change of Plumage of the Cinnamon Tree-Sparrow (Passer cinnamomeus). By G. A. Perreau. *Ibid.*, 986.

The nesting of a few somewhat rare birds near Mhow. By Lieutenant-Colonel R. M. Betham. *Ibid.*, 988.

Birds nesting in Gharwal. By S. L. Whymper. *Ibid.*, 990.

Breeding of the masked wagtail (Motacilla personata) in Kashmir. By Colonel L. L. Fenton. *Ibid.*, 992.

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Note on Inglis's Bush Quail (Microperdix inglisi, Grant). By Chas. M. Inglis. *Ibid.*, 993.

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Second occurrence of the snipe-billed Godwit in Assam. By E. C. Stuart Baker. *Ibid.*, 994.

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The game birds of India, Burma and Ceylon. By E. C. Stuart Baker, F.L.S., F.Z.S. Vol. xx, 1910, 1 and 259.

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The races of Indian rats. By the same author Vol. v, 1910, 105.

In the *Journal of the Bombay Natural History Society.* A young Kyang or Tibetan wild ass (Equus hemionus). By F. M. Bailey, with a plate. Vol. xix of 1909, 731.

On the local form of the Chinese Toddy-Cat taken in North Burma. By Captain A. W. Kemmis (Paguma larvata intrudens, subsp. n.) By R. C. Wroughton. Vol. xix, No. 4, 1910, 793.

The Serows, Gorals and Takins of British India and Straits Settlements. Part I. By R. I. Pocock, F.L.S., F.Z.S., Superintendent, Zoological Society's Garden, London. *Ibid.*, 807.

Note on the Serow (Nœmorhedus bubalinus) from the Chumbi Valley. By Captain F. M. Bailey; with a plate. *Ibid.*, 822.

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Some notes on the giant squirrels of India, Burma and Ceylon. By R. C. Wroughton, F.Z.S. *Ibid.*, 880.

On the food of the Desert Gerbille. By E. Comber. *Ibid.*, 978.

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The Serow from Upper Burma. By C. B. Moggridge. *Ibid.*, 981.

On the nomenclature of the Indian Hedgehogs. By R. C. Wroughton, F.Z.S. Vol. xx, 1910, 80.

Food of the Hoolook or white-browed gibbon. By J. C. H. Mitchell. *Ibid.*, 512.

List of papers, memoirs and books published in Europe and America having a special reference to Indian Zoology.

General.

Ueber die Geschichte der Tierwelt von Ceylon. Von Fritz Sarasin. Abdruck aus des Zoologisches Jahrbüchern. Tafel 1-3. Supplement 12, Heft 1, 1910 (Gustav Fischer in Jena).

Text-Book of Practical Zoology for Indian Students. By Major R. E. Lloyd, M.B., D.Sc., Professor of Biology, Calcutta Medical College. Published by Messrs. Longmans Green & Co., London.

Coelenterates.

Madreporaria. By Ruth M. Harrison and Margaret Poole (in the collection, Marine Fauna from the Mergui Archipelago, Lower Burma, made by Jas. J. Simson, M.A., B.Sc., and R. N. Rudmose-Brown, B.Sc.). Proceedings of the Zoological Society of London. Vol. ii, part iv, 1909, 897.

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Nemerteans from Eastern Indian Ocean (with descriptions of new species). By R. C. Punnett and C. Forster Cooper. Trans. Linn. Soc. Zool. Vol. xiii (1909), 1. (Plates and map.)

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Rhynchotal Notes (Homoptera. Fam. Fulgoridæ. Subfam. Ricaniinæ). By W. L. Distant. *Ibid.*, 320.

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On some Coccid Pests of Economic Importance. By E. Ernest Green, F.Z.S. Journal Economic Biology, Vol. vi, Part I, 1910.

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On some Asiatic species of the Branconid sub-families: Rhogadinæ, Agothinæ and Microgostenmæ and of the Alysudæ. By P. Cameron. (Including many new species from Indian region.) Wiener Entomologische Zeitung. Jahrgang xxix, Heft l, 1910. Wien.

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Land and freshwater Mollusca of India. By Lieutenant-Colonel H. H. Godwin-Austen, F.R.S., F.R.G.S., F.Z.S., &c., Sub-family Macrochlamyinæ. With descriptions of over 50 new species. Part xi, Vol. ii, 1910 (March). R. H. Porter, 7, Princes Street, Cavendish Square, London.

Ueber Birene Mollusken aus Turkestan, Kaschmir und West Tibet. Von Alois Weber: Zoologische Jahrbücher, Band xxix, Heft 4, 299, Jena.

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(Primitive vertebrates).

Hemichordata.

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Asiatic Fishes of the family Anabantidæ. With plates. By C. Tate Regan, M.A., F.Z.S., Proc. Zool. Soc. London. Vol. ii, 1909, 767.

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On the Birds of Kohat and the Kurram Valley, Northern India. By Lieut. C. H. T. Whitehead, with an Introduction by Major H. A. F. Magrath. (Additions and corrections.) Ibis., Vol. iii of 1909, p. 620.

On some new species of silver Pheasants from Burma, Manipur, Khasia Hills, Commillah and Goalpara. By Eugene W. Oates. Ann. Mag. Nat. Hist. 8th series, Vol. v, 1910. No. 26, p. 140.

The birds of India. By Douglas Dewar, F.Z.S., I.C.S. The Annual Report of the Board of the Smithsonian Institution for 1908. Washington, 1909.

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Ricerche di Sistematica Sperimentale sul Genera *Gennaeus*—Memoria del Prof. Alessandro Ghigi. Memorie della R. Accademia delle Scienze dell'istituto di Bologna, (Sezione dello Scienze Naturali), Serie vi, Tomo vi. 1910.

Mammals.

Descriptions of apparently new species and sub-species of Monkeys of the genera Callicetus, Lagostrix, Papio, Pithecus, Cercopithecus, Erythrocebus and Presbytes (including three new species of Langurs from within Indian limits). By Dr. D. G. Elliot, D.Sc., Ann. Mag. Nat. Hist. Vol. iv, 1909. (Series 8th), 244.

Two new Oriental Viverridæ. By Ernest Schwarz. *Ibid.*, Vol. vi, 1910, 230.

"The evolution of the Elephant." By Richard S. Lull, Ph.D., Curator, Yale University.

"The frontlet of a Mishmi Takin (Budorcas taxicolor). By P. Chalmers Mitchell. Proc. Zool. Soc. London, Vol. ii, 1909, Part iv, 741.

Note on the Manipuri Yek. By Lieut.-Col. J. Shakespeare, C.I.E., D.S.O., Vol. X, No. 4, Art. 33. "Man," published by the Royal Anthropological Institute, London.

Ein Kreishornschafbock mit Stelzbein. (Ovis cycloceros, Hutton). Zoologischer Beobachter Einundfiinfzigster Jahrgang, No. 7 of 1910, p. 202.

Morphology of the Manus in Platanista gangetica, the dolphin of the Ganges. By Sir William Turner, K.C.B., D.Sc., LL.D., F.R.S. Proc. Roy. Soc. Edin. xxx (1910), Part 6, p. 508.

AGRICULTURAL ENTOMOLOGY.

BY

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,
Imperial Entomologist.

The study of the insect pests of crops was continued at the Pusa Research Institute, and by the Assistants in Provincial Agricultural

Departments. The life-histories of injurious species were worked out at the Pusa Insectary, the further study made on the Pusa Farm and in the district. The more important of which the life-history was done were the:—

Palm Weevil (*Rhynchophorus ferrugineus*).
Rhinoceros Beetle (*Oryctes rhinoceros*).
Army Worm (*Cirphis unipuncta*).
Rice Swarming Caterpillar (*Spodoptera mauritia*).
Deccan Grasshopper.
Wheat Stem Borer (*Sesamia uniformis*)
Pink Bollworm (*Gelechia gossypiella*).
Indigo Leaf Webber (*Ypsolophus ochrophanes*).
Dusky Cotton Bug (*Oxycarenus lactus*).
Wheat Weevil (*Calandra oryzae*).
Rice Grain Moth (*Sitotroga cerealella*).

A study is being made of the White Ant (*Termes obesus*) and methods of checking it are being tested in conjunction with the Deputy Director of Agriculture, Northern Circle, Central Provinces. In collaboration with the Imperial Agricultural Chemist, an enquiry was made into the amount of dessication required to inhibit weevil in wheat. The investigation of the food of birds was completed by Mr. C. W. Mason. Insecticides sent in for trial were tested and a new insecticide of indigenous manufacture has been adopted and recommended, all imported ones being too costly. The question of Apiculture is being considered and attempts made to ascertain if bees can be profitably kept in the plains.

Investigation into Eri silk has been limited to the study of disease, in collaboration with the Imperial Agricultural Bacteriologist, and to the question of hybridising. Hybrid races of Eri (*Attacus ricini*) and of the wild form (*Attacus cynthia*) have been obtained and are being propagated; these may have an important influence on eri cultivation as the strains are hardier and less liable to disease. In regard to mulberry silk, enquiry has been directed mainly to the question of producing better multivoltine races by hybridising univoltine European with multivoltine Indian races and this will be continued. In lac, an attempt is being made, in conjunction with the Forest Department, to obtain material for discriminating the number of distinct races or species of the lac-insect, which is at present wholly unknown. Cultivation of lac is done on a small scale at Pusa and an attempt is being made to introduce and grow babul lac, an apparently distinct race which might be very extensively cultivated on waste lands on existing babul trees.

The work of Provincial Assistants has been mainly field-work with insects destroying the crops and local investigation into the occurrence of pests. In Madras, the work is very advanced and in almost every district the occurrence of pests has been investigated, as a preliminary to systematised campaigns to check them. Special attention has been paid to the Hairy Caterpillar pest of South Arcot (*Creatonotus albistriga*, Wlk.) and to the Deccan Grasshopper (a *Pyrgomorphid* of undescribed genus). The latter has also been studied in Bombay, and remedial measures for the Potato Moth (*Phthorimæa operculella*) carried out. In the Central Provinces, the work against Potato Moth was continued and work begun against the White ant (*Termes obesus*). In the United Provinces the work against the Cane Grasshopper (*Hieroglyphus furcifer*) has been continued. In the Punjab some experimental work has been done with bee-keeping in the hills and with sericulture.

The work in progress with biting flies, as affecting cattle, has made little progress owing to the absence of the Second Imperial Entomologist.

In Mysore, the Mycologist and Entomologist, Mr. L. C. Coleman, has studied the general pests of the State and especially the Deccan Grasshopper and the Dusky Ground Beetle (*Opatrum* spp.). Mr. R. D. Anstead, Scientific officer of the United Planters' Association of Southern India, has investigated methods of checking the green Bug and brown Bug of coffee and the pests generally occurring on coffee, tea, rubber, pepper, etc., in South India. Mr. C. B. Antram, Entomologist to the Indian Tea Association, has continued his work against the tea Mosquito (*Helopeltis theivora*).

The issue of coloured plates illustrating the life-histories of injurious and beneficial insects has been continued and these have been very largely circulated and used by Provincial Agricultural Departments. Publications in Agricultural Entomology during the year are few, the most notable being "Fasaler Poka," a revision in Bengali (with 20 coloured plates) of Indian Insect Pests. The record of advance in this subject grows smaller as the practical applied work absorbs the attention of the available workers, and while the practical applied work is yearly growing as the value of Agricultural Entomology becomes more generally recognised, the staff for both enquiry and practical work remains the same. The position is growing less and less favourable for the prosecution of any careful research or investigation, though the need for research grows as the subject expands.

Publications.

Text-books.

H. MAXWELL-LEFROY. . Indian Insect Life.
C. C. GHOSH . . Fasaler Poka (Bengali Revision of Indian Insect pests.)

Journal Articles.

VOL. V, No. 1, H. MAXWELL-LEFROY AND G. EVANS . Storage of Seed Potatoes.
VOL. V, No. 2, H. MAXWELL-LEFROY . A New Insecticide.
VOL. V, No. 2, H. MAXWELL-LEFROY . Tukra Disease of Mulberry. (Also in the Bengal Agri. Journal).
H. MAXWELL-LEFROY . . . Three Journal Reviews and three Notes.

Memoirs of the Department of Agriculture.

VOL. II, No. 8, H. MAXWELL-LEFROY . Life-histories of Indian Insects. Coleoptera I.

Bulletins.

H. MAXWELL-LEFROY . Vernacular Names. (In the press).

Leaflets.

Instructions for rearing Eri silk-worms. (In English, Hindi, Bengali) Eri seed exchange.

Other Contributions.

H. MAXWELL-LEFROY . Weevil in Wheat. (*Indian Trade Journal, Vol. XV, No. 190*).

Bulletins of the Indian Tea Association.

No. 1 of 1910, C. B. Antiam. The Mosquito Blight of Tea.

FOREST ENTOMOLOGY.

BY

V. SUBRAMANIA IYER, M.A., F.L.S.,

Forest Zoologist.

This branch of the Research Institute was engaged in the investigations of :—

(*a*) Sal-insect pests of the United Provinces and Central Provinces.

(*b*) Insect pests of the Himalayan Coniferæ.

(*c*) The damage done to Babul plantations in Berar by rats and a longicorn borer.

(*d*) The Life-histories of the predaceous and parasitic insects of the Lac-scale.

(*e*) The classification and cataloguing of the insects collected during the last 10 years for the College and the Institute by the officers of the Department.

(*f*) Damage to one-year old Sal-seedlings owing to an attack by caterpillars of *Pammene Theristis*, Meyr. on the roots in the Dechouri Range of the Kumaon Division, United Provinces. The investigation was started towards the end of February last, but little progress was made in the study of the Life-history of the moth which was, however, successfully bred out in the Laboratory at Dehra Dun and was subsequently identified by Mr. Meyrick as *Pammene Theristis*, Meyr. It is proposed to continue the investigation of this subject during 1910-11.

(*g*) The Casuarina insect pests of Madras (East Coast). This investigation was undertaken during May and June last in Nellore, North and South Arcot, Districts of the Presidency of Madras and the report which will shortly be submitted for publication deals with the Life-history of *Arbela tetraones* (Moore) and other insects that infest Casuarina on the East Coast of Madras.

During the year under review the time of the Zoologist was also taken up with :—

(*a*) Identification of insects for the benefit of Forest officers and others interested in Forest Entomology.

(*b*) Furnishing of information regarding the Life-history of known insect pests with suggestions of remedial measures for their eradication.

(*c*) Setting up of Show-cases of Injurious Forest insects for the benefit of the students of the Imperial Forest College.

List of Publications.

1. STEBBING, E. P. . Second monograph on some undescribed Scolytidæ (*Indian Forest Memoirs, i, Part ii.*)
2. STEBBING, E. P. . Note on some Insect pests of the Himalayan Oaks. (*Indian Forest Records, ii, Part i.*)
3. STEBBING, E. P. . Scolytus major. (*Leaflet No. 4, Forest Zoology series.*)
4. STEBBING, E. P. . Polygraphus major. (*Leaflet No. 5, Forest Zoology series.*)

VETERINARY SCIENCE.

BY

MAJOR F. S. H. BALDREY, I.C.V.D.,
Officiating Imperial Bacteriologist.

The output of various products at the Imperial Bacteriological Laboratory, Muktesar, will be observed from the following table:—

NAME.	Quantity prepared, doses.	Quantity issued, doses.
Anti-Rinderpest Serum	409,078	446,981
Hæmorrhagic Septicæmia vaccine . . .	8,320	9,960
Anti-Anthrax Serum	12,168	12,404
Charbon Symptomatique Pillules . . .	20,350	20,900
Mallein	9,515	10,137
Tuberculin	444	469
Strangles vaccine and serum (on trial) . .	5,753 c.c.	2,583 c.c.

Rinderpest.—The output of serum has been considerably increased by the application of the Peritoneal Washing method. This technique has been improved and rendered of practical benefit so that the amount of inoculable material for hyper-immunisation purposes has been increased. This in spite of the fact that the number of animals obtained has been less in weight and numbers than heretofore. The success of this method is a matter for congratulation.

Further experiments are now being conducted in other methods of increasing material by incubation, etc.

Hæmorrhagic Septicæmia.—Experiments have lately been conducted in the methods of contagion and natural immunisation by feeding, etc. A series of observations will also shortly be made as to the feasibility of obtaining a sensitised vaccine for this disease. The whole will form the subject of a special Memoir.

Anthrax.—There are some hopes that a vaccine which is harmless and has lately been tried in the Laboratory may prove in a measure successful, but it is too early to say anything definite. The serum prepared is a powerful one and gives immunity for about five weeks.

Surra.—A series of observations have been conducted as to the method of fly infection. This will form the subject matter of a special paper. The successful treatment by arsenic has been confirmed and the following cases have been treated and cured.

In our hands we have been able to cure about 80 per cent. of cases treated. The treatment was subjected to the most severe test it is possible to apply.

Twenty ponies from the Transport Corps were sent to the Laboratory in October 1909. These ponies had contracted Surra on the Kathgodam road. They were in the last stage of the disease, entirely emaciated, and hardly able to walk. They were aged ponies, most of them well over sixteen years. Out of these twenty ponies, two died from colic not attributable to the treatment and two died from cerebritis. Nine were returned to work at end of January 1910, having been under observation three months from the termination of treatment. Seven others were returned to the Transport at the end of March 1910.

These also were kept under observation for three months. Further experiments have been made in the treatment of camels by the use of adventitious drugs with Arsenic.

A report will be submitted on this method.

Charbon Symptomatique.—A serum was prepared with a view to its use in actual outbreaks where the use of vaccine is attended with danger. This serum has been tested in the Laboratory but not yet used in the field.

Lymphangitis, Contagium of cattle.—An organism causing symptoms similar to those described by Colonel Raymond in the Journal of Tropical Veterinary Science has, during May, been investigated and is the subject of a paper.

A List of Publications contributed during the year 1909-10 from the Imperial Bacteriological Laboratory.

BALDREY, F. S. H. . Annual Report of the Imperial Bacteriological Laboratory for the year 1909-10.

BALDREY, F. S. H. . Some Original Notes on the Comparative immunising Properties of Vaccine and Agressions in Schweineseuche. (*Jr. of Trop. Vety. Sci. v, No. 1, 46.*)

BALDREY, F. S. H. . Notes and observations on the Evolution of T. Lewisi in the Rat Louse, *Hæmatopinus spinulosa.* (*Jr. of Trop. Vety. Sci. v, No. 1, 101.*)
Also *Archiv für Protistenkunde.*

HOLMES, J. D. E. . Further Experiments on the Treatment of Surra with Atoxyl and other preparations of Arsenic. (*Jr. of Trop. Vety. Sci. iv, No. 3, 286.*)

HOLMES, J. D. E. . The Treatment of Surra in Horses, by means of Arsenic and its Derivatives. Thirty-two cases of Successful Treatment. (*Jr. of Trop. Vety. Sci. v, No. 1, 1.*)

A List of Papers published during 1909-10 bearing on such diseases.

ARGYLE, CAPT. E. P. . Some Notes on Equine Filariasis. (*Jr. of Trop. Vety. Sci. v, No. 1, 96.*)

CLELAND, J. B. . . Trypanosomiasis and other Diseases of Camels with Experiments in connection with the former. (*Jr. of Trop. Vety, Sci. iv, No. 3, 316.*)

CORNWALL, J. W., & KESAVA PAI, M. The Diagnosis of Rabies in Inoculated Animals. (*Jr. of Trop. Vety. Sci. v, No. 1, 149.*)

CORNWALL, J. W., & KESAVA PAI, M. — The Measure of Immunity against Rabies in Animals. (*Jr. of Trop. Vety. Sci. v, No. 1, 156.*)

CORNWALL, J. W., & KESAVA PAI, M. — Negri Bodies. (*Jr. of Trop. Vety. Sci. v, No. 1, 162.*)

DAWSON, W. O., & GAIGER, S. H. — *Trichorrhexis nodosa* in the Horse. (*Jr. of Trop. Vety. Sci. iv, No. 3, 307.*)

DEY, D. . . . — *Coenurus serialis* in a Goat. (*Jr. of Trop. Vety. Sci. iv, No. 4, 556.*)

EVANS, G. H. . . — "Elephant Surra" Trypanosomiasis in the Elephant. (*Jr. of Trop. Vety. Sci. v, No. 2, 233.*)

EVANS, G. H., & RENNIE, T. — Notes on some parasites in Burma, III. (*Jr. of Trop. Vety. Sci. v, No. 2, 240.*)

FRASER, H. . . — Surra in the Federated Malay States. (*Jr. of Trop. Vety. Sci. iv, No. 3, 345.*)

FREER, G. W. . . — Ephemeral Fever or Three Days' Sickness in Cattle. (*Jr. of Trop. Vety. Sci. v, No. 1, 145.*)

GAIGER, S. H. . . — Contribution to the study of Hæmorrhagic septicæmia. (*Jr. of Trop. Vety. Sci. iv, No. 4, 501.*)

GAIGER, S. H. . . — *Filaria Osleri* in India. (*Jr. of Trop. Vety. Sci. iv, No. 4, 525.*)

GAIGER, S. H. . . — *Linguatula tænioides* (*Jr. of Trop. Vety. Sci. iv, No. 4, 528.*)

(I) Treatment of Camel Surra.

(II) An Extraordinary case of Resistance to Camel Surra in the Dog.

(III) Some attempts at Treatment of Surra in the Dog. (*Jr. of Trop. Vety. Sci. iv, No. 4, 546.*)

GAIGER, S. H. . . — Contagious Gastro-Enteritis in Dogs. (*Jr. of Trop. Vety. Sci. v, No. 1, 52.*)

GAIGER, S. H. . . — A Preliminary Check List of the Parasites of Indian Domesticated Animals. (*Jr. of Trop. Vety. Sci. v, No. 1, 65.*)

GAIGER, S. H. . .	Rabies. (*Jr. of Trop. Vety. Sci. v, No. 2, 277.*)
GIBSON, ADAM . .	A Method of dealing with Rinderpest in the Field. (*Jr. of Trop. Vety. Sci. v, No. 1, 93.*)
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JOWETT, W. . .	Biliary Fever or Malignant Jaundice of the Dog. (Canine Piroplasmosis.) The Drug Treatment. (*Jr. of Trop. Vety. Sci. v, No. 2, 257.*)
LEESE, A. S. . .	The Normal and Abnormal Temperatures of the Camel, with a Note on Normal Pulse and temperature. (*Jr. of Trop. Vety. Sci. iv, No. 3, 300.*)
LEESE, A. S. . .	Note on Tapeworms in Punjab Camels. (*Jr. of Trop. Vety. Sci. iv, No. 3, 305.*)
LEESE, A. S. . .	Summary of first series of Experiments on Treatment of Surra in Camels. (*Jr. of Trop. Vety. Sci. v, No. 1, 57.*)
LEESE, A. S. . .	Filariæ in Vitreous Chamber of the Eye of a Camel, Ophthalmia. (*Jr. of Trop. Vety. Sci. v, No. 1, 89.*)
MITTER, S. N. . .	A case of generalised tuberculosis in a Macacus. (*Jr. of Trop. Vety. Sci. v, No. 2, 281.*)
MITTER, S. N. . .	Gnathostomum spinigerum in a Domestic Cat. (*Jr. of Trop. Vety. Sci. v, No. 2, 284.*
NUTTALL, G. H. F., & HADWEN, S.	The Successful Drug Treatment of Canine Piroplasmosis. Together with Observations upon the effect of Drugs on Piroplasma Canis. (*Jr. of Trop. Vety. Sci. v, No. 1, 106.*)
OLD, J. E. S. . .	Contributions to the study of Trypanosomiasis and to the Geographical Distribution of some of the Blood-sucking Insects, etc. (*Jr. of Trop. Vety. Sci. iv, No. 3, 395.*)
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PROGRAMMES OF WORK FOR 1910-11.

PROGRAMMES OF WORK OF THE VARIOUS SCIENTIFIC DEPARTMENTS FOR THE YEAR 1910-11, AS APPROVED BY THE BOARD ON THE 9th MAY 1910.

1.—Department of Economic Products, Calcutta, and Imperial Institute, London.

1. **Turpentine.**—The chemical investigation of the hydrocarbons of Indian turpentine at present in hand at the Imperial Institute will be concluded there.

2. **Fragrant Gums.**—The examination and identification of the plants yielding the various trade forms of myrrh, frankincense, mastic, byssabol and other like products from the Gulf of Aden, Arabia and the Persian Gulf will be continued. The gums are further being examined chemically so that the subject is under study as a whole both from the botanical and from the chemical standpoint.

3. **Lac.**—The study of the chemical constants of various forms of lac will be continued. This investigation is connected with a study of the effect of adulterating shellac with resin.

4. **Dyes.**—As a sequel to the publication of the Agricultural Ledger No. 2 of 1908-09 on dyes from Indian flowers, came an offer of assistance in the investigation of the subject from Professor A. G. Perkin. Very gladly the offer was accepted, and material for a chemical study of such flowers as are used and have not been investigated is being forwarded to him. The minor investigation on the dyeing properties of *Baccaurea sapida* is still in hand.

5. **Oils.**—The minor investigation on the utility of the oil of "Tannoom" (*Chrozophora verbascifolia*) will be completed if material can be obtained and so will that on the variability of the oil of *Amoora Rohituka*. The important survey of Indian fixed oils will be brought to a finish by the publication of descriptions, characters and classification of those that are known.

6. **Citronella Oil.**—The results of work to date will be published, and the publication will serve as a link between the work of the Reporter on Economic Products and that of the Forest Department.

7. **Fibres and Paper.**—Work on jute-selection will be continued conjointly with the Fibre Expert to the Government of Eastern Bengal and

Assam. A few analyses are to be made of "Sabai" grass from various sources. Indian papers are being examined from the point of view of their composition.

8. **Food Grains.**—An attempt will be made to complete the review of the Indian races of juar (*Sorghum vulgare*) and an index of literature on races of rice in India will be published.

9. **Dioscorea.**—Indian Yams.—During the year, the monograph on these plants will be completed. It will comprise the classification of the genus, descriptions and figures of the species, notes on the cultivated races, on the jungle and famine foods derived from various species, and on their food value.

10. **Pulses.**—The work on Indian pulses will be prosecuted. The survey of those of Burma is being carried out conjointly with Mr. J. MacKenna, Director of Agriculture, Burma, under whose instructions many are being cultivated for better observation. The work on the Soy bean—*Glycine Soja*—consists of a botanic study of the races in India together with chemical examinations by Mr. D. Hooper. The work of "Khessary" comprises the cultivation for the purposes of observation of many samples, which have been sown in the Royal Botanic Gardens, Calcutta, by the kindness of Major A. T. Gage. The study of "San" hemp has involved some special examination of material collected in Eastern Bengal.

11. **Caraway.**—All the material available for study here has been lent to the Royal Botanic Gardens, Kew: so that the botanic investigation named in earlier programmes is still proceeding, but in England instead of in the Indian Museum.

12. **Turmerics, Curcumas and other Scitamineæ.**—The investigation is proceeding on two main lines, (*i*) the study of such plants as yield starch, and (*ii*) the collection of an index series of roots to serve as standards for the identification of the several belonging to the *Scitamineæ* which are sold as drugs. The amount of starch, oil and colouring matter in the various roots will be estimated.

13. **Gentians.**—The identity of all medicinal bitters derived in Eastern Asia from this group of plants is being established.

14. **Aconites.**—The study of the chemistry and physiology of our Indian Aconite roots is in progress in the hands of Professors Dunstan and Cash.

15. **Hemp Drugs.**—It is proposed to assist Professor C. R. Marshall of Dundee in any way possible in his enquiry upon the chemistry of the active substances in "Charas."

16. **Solanaceous Alkaloids.**—The study of these is in progress in the hands of Professor Dunstan.

17. **Colchicum luteum.**—A physiological and chemical study of the roots of our small Indian Colchicum is in progress on material sent by the Reporter on Economic Products to Cambridge.

18. **Peganum Harmala.**—A chemical study of the seeds of this drug is in progress at Manchester on material supplied by the Reporter on Economic Products to Professor J. F. Thorpe.

19. **Thalictrum foliolosum.**—A chemical study of the roots of this medicinal plant is in progress in the hands of Professor Dunstan on material supplied by the Reporter on Economic Products.

20. **Saponin.**—Professor Schaer of Strasburg is endeavouring by work on material supplied by the Reporter on Economic Products to ascertain how many forms of Saponin are in the vegetable kingdom.

21. **Indigenous Drugs.**—The work of the Indigenous Drugs Committee will be continued. The full programme cannot yet be given but one important piece of work will be a further examination of the effect on its efficiency of digging *Podophyllum Emodi* at different stages of maturity.

22. **Poison to Stock.**—The collection of information on plants poisonous to horses, cattle, etc., is in progress, and botanic specimens will be collected as far as possible and sent to the various military institutions requiring them for teaching purposes.

Of the above, the following are new investigations or parts of investigations :—

(*i*) Index to the literature on rice.
(*ii*) Estimation of the amount of oil in the Soy bean in India.
(*iii*) Chemical investigation on dyes from flowers.
(*iv*) Turmerics, etc.
(*v*) *Peganum Harmala.*
(*vi*) *Thalictrum foliolosum.*

The following are in hand at the Imperial Institute, Nos. 1, 2 and 4 being conducted on material supplied by the Reporter on Economic Products :—

1. Completion of the work on Indian Daturas.
2. Examination of the constituents of the Indian Aconites.
3. Examination of Indian opiums.
4. The completion of the determination of the hydrocarbons of Indian turpentines.

2.—Meteorological Department.

Meteorology.

1. **Sounding balloons.**—It is proposed to make a series of ascents throughout 12 months, beginning as soon in 1910 as the necessary instruments have been completed, probably at the end of March. Two balloons will be liberated weekly, each carrying an instrument to record temperature, pressure and humidity during ascent and descent, while the vertical and horizontal velocities of the balloons will be found, and their paths plotted, from observations taken in the ordinary way by theodolites at the two ends of a measured base line. As far as possible the days chosen in each month by the International Commission will be observed, in order that India may contribute to the data of simultaneous upper air conditions which are now being rapidly accumulated. This work will be carried out at Jhang in the Punjab where the experiments with such balloons have hitherto taken place.

2. **Kites.**—The work with balloons will, it is believed, tax the department as far as is practicable, and it will not therefore be possible to supplement that work by the use of kites.

3. **Atmospheric electricity.**—Continued observations will be made of the chief factors of atmospheric electricity. These are :—The electric potential gradient; ionization, conductivity and radio-activity of the air; the earth-air current, and the quantity of electricity carried down by rain and snow.

4. **Seasonal variations of weather.**—It is proposed to continue the search for relationships between these variations in different parts of the earth, and to try to find physical explanations in certain cases.

Astronomy : Solar Physics.

5. **Photographing the sun in ordinary light.**—This will be continued as in former years.

6. **Record of sunspots.**—As before.

7. **Record of prominences.**—As before.

8. **Sunspot spectra.**—These will be studied both visually and photographically as before.

9. **Halley's Comet.**—It is proposed to take as complete a series as possible of photographs of this comet, while it is suitably situated for observation, with the camera attached to the Lerebour and Secretan equa-

torial and with a smaller camera attached to the same instrument. Attempts will also be made to photograph the spectrum with a prismatic camera and with a slit spectrograph used in connection with the 18-inch silver-on-glass mirror.

10. **Variations in the quantity of radiation emitted by the sun.**—Photographs of extra-focal images of stars and of the moon reflected from a convex quartz surface will be continued with a view to detecting variations in the solar constant and variations in relative emissive power in different regions of the spectrum.

11. **Photographing the sun in monochromatic light.**—The routine work with the spectro-heliographs will be continued, and in addition photographs in H light will be taken with the new auto-collimating grating spectro-heliograph.

12. **Spectra of sunspots :—**

(*a*) Studies in the radial movement in spots will be continued.

(*b*) Attempts will be made to detect vertical movements in the umbræ.

(*c*) Displacements of lines due to pressure effects in spots will be studied.

13. **Displacements of lines at the sun's limb.**—It is proposed to continue the research into the cause of the shift of the lines towards the red at the sun's limb, using a series of high dispersion spectra of limb and centre already secured with the Michelson grating. Particular attention will be given to the shifts of the lines which are most and least affected by pressure.

Seismography.

14. The three Omori seismographs, two in Simla and one in Bombay, and the Milne seismographs at Calcutta, Kodaikanal and Bombay will be kept in use during the year.

3.—Survey of India (Scientific Research Work).

Gravimetric Survey.—Pendulum operations in Rajputana in the area between Latitudes 24° and 27° and Longitudes 79° and 82°.

Magnetic Survey.—Colaba Observatory under the Meteorological Reporter and the four Observatories under the Surveyor General will continue to work. Observations will be taken at repeat stations and at certain selected old field stations and detailed surveys of disturbed areas will be continued.

Latitude Operations.—Latitude observations south of the Himalaya of Central and Eastern Nepal on the N. E. Longitudinal series up to Sonakhoda and commencement on the North Maluncha and North Parasnath Meridional Series.

Solar Photography.—Photographs of the sun will be taken daily at 10 A.M. and 4 P.M., at Dehra Dun, as has been done since 1879 in conjunction with Greenwich.

4.—Geological Survey.

Part A.—*Subjects undertaken during previous years to be continued.*

(1) Geological Survey of Upper Burma.
(2) Revision of the Survey of Central India and Rajputana.
(3) Investigation of samples of salt from Rajputana and the Punjab Salt Range.
(4) Mapping of unsurveyed areas in the Central Provinces.
(5) Survey of oil-bearing regions in North Eastern Assam.
(6) Economic Survey of the Dhalbhum Estate.
(7) Survey of the Idar State in the Bombay Presidency.
(8) Search for mammalian remains in the Siwalik rocks of Jammu and Kangra, and revised classification of freshwater Tertiary strata.
(9) Palæontology of (*a*) the Liassic beds of Baluchistan, (*b*) the Cretaceous and Tertiary systems of Tibet, (*c*) the Indian Tertiary mollusca, (*d*) Jurassic brachiopoda from the Northern Shan States, and (*e*) study of the Siwalik vertebrates.

Part B.—*New questions.*

(10) The examination of the Lonar Lake salts.
(11) Survey of the oil-bearing strata of the Rawal Pindi district.
(12) Artesian water-supply in Gujarat and other places.
(13) Sulphide ores in the Punjab Salt Range.
(14) Palæontology of (*a*) Silurian fossils, (*b*) Permo-Carboniferous and Triassic fossils, and (*c*) Gondwana plants from Kashmir.

5.—Botanical Survey.

Work already in progress.—The Superintendent of the Royal Botanic Garden will continue the compilation of a catalogue of the non-herbaceous plants cultivated in the Royal Botanic Garden, Calcutta.

The Curator of the Herbarium will finish his account of the botanical results of the expedition to Lonakh in the North-West of Sikkim.

An account of the botanical results of Mr. Meebold's tour through Manipur and Burma will be elaborated for publication.

Mr. I. H. Burkill's account of his trip into Nepal will appear.

New work.—Two Indian Assistants will be trained to Herbarium work in the first instance and, if possible, field work also. A commencement will be made in forming photographic records on a suitably large scale of typical views of Indian vegetation and of typical Indian plants.

The Curator of the Herbarium will be deputed to study in the field the flora of the South-Eastern area of Sikkim in the same way that he has done the North-Western area of the same province.

Signor Beccari's account of the genus *Dæmonorops* of climbing palms will, it is hoped, appear during the year.

Work by associated officers.—The Director of the Botanical Survey has been informed that there is little prospect of the Government Botanist, Madras, being able to do any systematic botanical work.

The Economic Botanist to the Government of Bombay states that he is to undertake the collection and identification of flowering plants from all parts of the Bombay Presidency. He proposes to make a special study of the genus *Tamarix* and to make a catalogue of the hosts of certain parasites, chiefly *Loranthus* and *Cuscuta*.

No botanical work bearing on the Botanical Survey of India is to be undertaken by the Economic Botanist to the Government of the United Provinces.

6.—Agricultural Department.

I.—Agricultural Research Institute, Pusa.

The scientific work of the Institute for the coming year is indicated under the programmes of the different sections.

The Prospectus of the Institute and College, as revised by the Board of Agriculture, 1909, and finally approved by the Government of India, has been published and the courses given in the several sections will be on the lines indicated therein.

For the benefit of *bonâ fide* agriculturists and the subordinate staff of the Agricultural Departments, specially short courses of a simple and practical nature have been instituted and instruction in these subjects will be continued.

II.—Agricultural Chemistry.

1. The work on the availability of plant food in soils will be continued, the immediate aim being the more correct ascertainment of the composition

of the aqueous solution in the soil. Included in this section of investigation are naturally the amounts of nitrate in soils and temperatures. It is intended to co-operate, if possible, in relation to this subject with the Imperial Bacteriologist.

2. The investigation on soil moisture and water requirements of plants is being continued on lines which have been sufficiently indicated in the memoirs.

3. A joint investigation with Mr. Burt, Deputy Director of Agriculture, United Provinces, is being conducted into the causes of infertility in a tract of land in the Mainpuri District.

4. The effect of soil and manure on the composition of crops is a branch of study which is engaging the attention of a number of investigators and is one on which I have already obtained some information. It will be developed at Pusa during the coming year.

5. Two points in relation to the Indian saltpetre manufacture, in respect of which it seems possible that an improvement can be suggested, will be investigated.

6. **Education.**—This requires no special comment; it will be conducted according to the lines laid down.

III.—Economic Botany.

1. **Training.**—The training of advanced students in this section will be continued on the lines laid down in the prospectus of the Institute. The course on fruit-growing will be given as usual in the cold weather.

2. **Plant breeding and plant improvement.**—During 1910 the following crops will be studied:—Wheat, tobacco, barley, oilseeds and fibre plants.

(*a*) **Wheat.**—The botanical survey of the wheats of Baluchistan will be completed. The production of improved varieties by selection and hybridization will be continued. The co-operative experiments on the effect of environment on the milling and baking qualities of Indian wheats, which are being conducted in collaboration with Mr. H. M. Leake, Economic Botanist to the United Provinces, and of which the earlier results are now in course of publication, are being continued on an extended basis. The above experiments include the effect of weathering on the quality of the wheat crop and the Imperial Bacteriologist has agreed to undertake the study of the bacteriological aspect of this subject.

(*b*) **Tobacco.**—The production of new varieties by selection and hybridization will be continued as well as the testing and curing of the varieties already isolated. The investigations on the influence of environment on the stability of the type and on the quality will be continued.

(*c*) **Oil-seeds.**—The study of the oil-seeds of India will be continued on similar lines to those adopted in the investigations on wheat.

(*d*) **Fibres.**—The isolation and testing of pure races of fibre plants of India will be continued.

(*e*) **Fruit.**—The fruit experiments will be continued on the lines laid down in the First Fruit Report.

(*f*) **Minor Investigations.**—The study of the varieties of cassava will be completed and the investigation on the inheritance of sex in ganja continued.

IV.—Mycology.

1. **Research and Experimental work.**—Owing to the opportunity for co-operation afforded by the appointment to Pusa of the Imperial Bacteriologist, it is proposed to resume the work on soil fungi which was temporarily abandoned two years ago.

The work on the wilt disease of crops, especially of indigo and cowpea, and if opportunity occurs, of cotton and gram, will be continued.

The investigation of sugarcane disease is being continued and the new results regarding red-rot will be published. The Supernumerary Mycologist is investigating the life history of sugarcane smut.

Assistance will be given on the campaign against the bud-rot disease of palmyra palms in the Godavari. An account of the parasite and a review of the work undertaken to prevent its spread will be published.

It is proposed to publish a preliminary account of the soft-rot disease of ginger based on the work of the last two years.

The study of some anthracnoses of leguminous crops, specially of *val* (Dolichos) and cowpea, will be begun.

2. **Training.**—The training of students in Mycology will be continued and the advanced course of Mycology will be given to those already in training; assistance will be given to Provincial Colleges in providing notes and material for Mycological instruction.

3. The collection and identification of Indian parasitic fungi will be continued. If possible a complete list of the ascomycetes in the Pusa Herbarium will be published and the text of the book of Indian Plant Diseases finished.

V.—Entomology.

1. **Research and Experimental Work.**—The work of the past year in studying and advising on crop pests will be continued. Assistance will be given, where desired, in directing the work of Provincial Assistants and in coping with any outbreaks of pests that may occur. So far as possible, all specimens of insects sent in will be identified and work in connection with the reference collection of insects of the plains will be continued. The issue of coloured plates of injurious and beneficial insects will be continued. Enquiries in progress on insecticides and spraying machines, fumigation, the danger of the importation of injurious insects and the value of parasites as checks on crop pests, will be carried on as time permits. The staff of the Second Imperial Entomologist will continue work in progress on mosquitos, biting-flies and fruit-flies. The cultivation of lac at Pusa will be continued and so far as possible assistance will be given to those wishing to start cultivation in agricultural areas. Eri silk cultivation will be continued as the basis of a possible cottage industry in several parts of India and assistance will be given so far as possible in starting the industry in new localities. The cultivation of mulberry silk will be continued chiefly with a view to giving advice to those who require it and to testing the possibilities of this industry in new localities. Tassar silk rearing will not be continued.

2. **Training.**—It is uncertain if any students will present themselves for the course of advanced entomology. If they do, this course will continue as before. Short courses in eri silk and lac cultivation will be given if required as also a course in sericulture. If possible, instruction in dealing with insects injurious to live-stock will be given as part of the course in cattle-breeding.

Publications.—A revision of the Indian Insect Pests in Bengali is being published; if time permits, the full revision of the text of Indian Insect Pests will be taken up.

VI.—Agricultural Bacteriology.

The Biological aspects of tillage in Indian soils.

This will involve investigations extending over a prolonged period, the basis of which would include a general investigation of the bacterial content of Indian soils.

Concurrently with this general investigation special observations will be made with the intention of determining the biological factors under-

lying certain problems of agricultural interest such as those connected with the custom of embanking wheat lands. They will also include enquiries into :—

1. The biological aspects of the availability of plant food in soils.
2. The biological factors concerned in the decomposition of organic matter in Indian cultivated soils.
3. Biological aspects of :—
   (*a*) Green manuring in India.
   (*b*) "Weathering" of soils.
   (*c*) Effect of ploughing land when too wet, before sowing.

No. 1 will be carried out in collaboration with the Imperial Agricultural Chemist, No. 2 in collaboration with the Imperial Mycologist and No. 3 in collaboration with the Imperial Economic Botanist.

VII.—Agriculture.

1. **Permanent Experiments.**—The permanent manurial and rotation experiments and the pasture experiments will be continued.

2. **Extension of Botanical Work.**—The growth of selected varieties of wheat will be taken up in extension of the work now being done by the Imperial Economic Botanist. This work will be carried on in consultation with and under the botanical surveillance of the Imperial Economic Botanist.

3. **Cattle-breeding.**—The local herd has been transferred to the Bengal Agricultural Department and the Montgomery herd will now be considerably increased. Improvements of this breed by selection based principally on milk tests will be the chief object in view. It is also intended to start a dairy.

4. **Sheep.**—The crossing of local and Bikanir ewes with Dumba rams will be continued.

5. **Poultry.**—Poultry breeding and distribution will be continued.

6. **Training.**—Courses in the practice of agriculture will be given as heretofore.

VIII.—Imperial Cotton Specialist.

I.—To visit and advise on points regarding cotton and its cultivation whenever requested to do so by Provincial Departments of Agriculture.

II.—By special invitation of the Department of Agriculture, Central Provinces, to make detailed investigations throughout the whole of the

cotton tracts of that Province in co-operation with the Deputy-Directors of Agriculture; a continuation of this research would probably have to be carried into Khandesh and Bengal; also to investigate into the distribution of superior varieties in the rich cotton tracts of the Nizam's Dominions especially those which lie along the Godavery river.

III.—As Bourbon and Buri Cottons appear to be two superior varieties most suitable for what are at present non-cotton-producing tracts, namely, those with a sandy or red soil or with a rainfall heavier than can be borne by indigenous varieties, it is proposed to carry out experiments with these, on lands furnished by the owners, in parts of Rajputana, near the Western Ghats, and perhaps Mysore. I understand that the officers of the Madras Agricultural Department are to undertake investigations into the Bourbon cultivation in the red soils of their Presidency.

IV.—The re-establishment of superior varieties in Kathiawar and other parts which substituted inferior drought resisting cottons during the famine year of 1899-1900.

IX.—Provincial Departments of Agriculture.

The programmes for 1910-11 generally follow those described in 1909-10. The following are, however, important additions :—

Bengal.—The Sabour College will likely be opened in November 1910. As a consequence, much of the time of the Principal, the Economic Botanist and the Agricultural Chemist will be occupied in the laying out of the Farm, the Botanical Garden, College grounds and the fitting up of the College Laboratory. Manurial and other varietal experiments with paddy, jute, sugarcane, wheat and maize will be continued. For the revival of sericulture industry in the Province, pure and disease-free seed will be supplied to silk-worm rearers from model nurseries under the control of the Department. Well-boring operations have been undertaken in Behar and will be continued as they indicate a possibility that very large supplies of water may be obtained from deep borings in South Behar. The work of classifying the different types of sugarcane in the Province will be continued in co-operation with the Economic Botanist. The experiments on the chemical selection of the canes are also being continued. At the Indigo Research Station, Sirsiah, attempts are being made to improve the indigo plant by selection and to study the causes which lead to the production of indican with a view to evolving some method of stimulating its production.

United Provinces.—The opening of Experimental Farms at Attara and Benares has been deferred owing to financial pressure. The principal crops

under study have been wheat, cotton and sugarcane. It is intended to carry on the classification of the wheats of the Province based upon the observation of the growing plant. Co-operative experiments on the effect of environment of the milling and baking qualities of Indian wheats are being extended, in collaboration with Mr. Howard, the Imperial Economic Botanist. Pure Indian types of wheat will be tested on a field scale at Cawnpore. Selection experiments with types of wheat best suited to Bundelkhand conditions as regards power of resistance to rust will be carried on at Orai. Pure selected Muzaffernagar wheat is being propagated at Cawnpore for distribution. Experiments with indigenous cottons will be carried on at Aligarh and attempts will probably be continued to establish American cotton on a commercial scale. Trials are being made to establish lac on dhak trees, *Butea frondosa*, growing on usar land. A study of alkali soils in a canal irrigated area has been taken up to determine the nature and distribution of the alkali salts, their variation laterally and vertically and with season and such other connected questions.

Punjab.—The site for the second Agricultural Station has been acquired at Gurdaspur and the laying out of the land for experimental purposes will be pushed on. The distribution of American cotton seed will be continued mainly in the Canal Colonies. A staff of well-borers will be organised for extension of well-irrigation where possible. Attempts to introduce the labour saving machinery tested by the Department will be continued. The Lyallpur Agricultural College has been opened and much time will necessarily be occupied in organising the teaching work. The Agricultural Chemist will investigate, as time permits, the whole question of the alkali lands of the province. The breeding of poultry will be taken up with a view to develop a cross between an English and indigenous breed to suit local conditions. The present condition of date-cultivation in the province will be investigated, the possibilities of its improvement and extension will be studied and a certain number of selected varieties will be planted. The experiments with cassava, flax and jute will be continued to determine whether they could be profitably introduced into the province. Further work on the classified wheats of the province will be undertaken to discover which of the selected varieties are best suited to the natural conditions of particular districts. Sericulture, apiculture and lac-culture have been taken up.

Bombay.—Cotton will continue to receive the major share of attention. The methods for improving cotton consist of (*a*) hybridization, (*b*) selection, and (*c*) trial of varieties in addition to experiments in manuring, irrigation,

tillage and the like. The cultivation of tobacco under shade is being investigated to determine the effect upon the texture of the leaf. As Nadiad tobaccos are markedly weak in potash, a suitable site in the same tract is being tested for laying out special experiments with potash manures on the recommendation of the Director of the Imperial Institute, London. The potato-moth will continue to receive special attention both in the field and in the store. A farm has been opened at Sukkur to introduce new crops, chiefly cotton, pulse and leguminous crops, into Upper Sind. The Agricultural Chemist proposes to study the method of dealing with the salt lands of the Nira Valley and other salt tracts in the Deccan. He will also investigate the sources and amount of loss in the manufacture of *gur* with a view to ascertain how they can be avoided and the bye-products utilised. The Economic Botanist proposes to study the varieties of the important local fruit crops with a view to description, classification and selection. Among new lines of work proposed to be undertaken by him are the study of (1) the possibility of extracting and using plantain fibre in a profitable manner, (2) the variations of the cotton leaf as indicated by Mr. Leake's leaf-factor, (3) the effects of crossing mango varieties, (4) comparison of budding and grafting the mango, (5) the pruning of the mango, and (6) the comparison of European and Indian methods of grape culture.

Madras.—The lands on the Farm at Bezwada recently taken over by Government will be brought to a condition fit for experiment. As the demand for Mauritius sugarcane in the Godaveri delta is practically over, their further distribution afield is being taken up. The Barbados cane, No. 208, introduced by the Department on the Samalkota Agricultural Station, having been a marked success, efforts will be made to spread it as rapidly as possible. At Palur, exotic and other varieties of groundnut are being tested and compared with the variety grown locally. Rotation and mixed cropping experiments of groundnuts and cereals will be continued to determine which has the best effect on the succeeding groundnut crop. In the ceded districts, where there is a much greater mixture of cotton varieties, the pure white-seeded variety called white "Northerns" is the most promising. Forty-five acres of land have, therefore, been taken up for growing seed of this variety for distribution. The cultivation of Karungani variety in Tinnevelly is being pushed. In the same district, arrangements have been made by the Department to bring into extensive use the method of sowing cotton with a drill, a practice previously unknown. Village depôts for the sale of seed will be extended to new

centres. The experiments on the water requirements of irrigated garden crops will be continued at Coimbatore. The diseases affecting the pepper vine will be investigated by the recently appointed Mycologist of the province.

Central Provinces.—Implement depôts of the type already existing in Nagpur and Hoshangabad have been started on a small scale at Akola and Raipur. At Jubbulpur, a small plot under a Government Irrigation work is to be taken up to demonstrate, after experiment, the most economical use of irrigation water in the crops and soils of the district. A similar plot will be taken up at Damoh in land embanked by the Irrigation Department to teach people how to use much of the land which, at present, lies fallow. A small plot is also to be taken up at Nimar to demonstrate the possibility of growing better varieties of cotton in that district. The various experiments with cotton as regards hybridizing, plant to plant selection, etc., carried on at Akola will be continued. An important experiment has been undertaken at Hoshangabad to test the double-cropping of embanked land on typical heavy soils. At Raipur, an experiment will be made to test the value of wild lucerne (*Melilotus alba*) both as a fodder crop and as a soil renovator for land which grows rice continuously without manure, as it is likely to be of great help in solving the manure and fodder question for Chhattisgarh. Demonstrations will be pushed on in the backward tracts of Chhattisgarh to extend transplantation of rice, irrigation of wheat and cultivation of cane and groundnut.

Burma.—The crops under investigation are paddy, wheat, cotton, jute, jowar and maize. As the area under groundnuts is increasing, experiments in their yield, percentage of oil to kernel and of kernel to whole seed have been begun in addition to varietal experiments. If the Hmawbi Farm is opened during the year, work there will consist in laying out operations. In the event of this farm not being opened, some initial experiments will be attempted with flood resisting paddies, a site being obtained in one of the flooded areas. The extent of damage done to cocoanut trees by the Rhinoceros Beetle will be investigated, with a view to evolve a scheme to check its ravages.

Eastern Bengal and Assam.—The principal crops under study are rice, jute, sugarcane, tobacco and groundnut. At Rajshahi, Upper Shillong and also at Haflong (in the North Cachar hills), attempts will be made to raise potato seed for distribution in connection with the efforts which are being made to promote the cultivation of Naini Tal and Darjeeling

potatoes. The experiments at Rajshahi having indicated that potatoes can be grown there successfully without irrigation, steps will be taken to popularise this crop in the district. Further work on tobacco at Burihat will depend upon the results of a flue-curing experiment which is being tried for the first time this year. Poultry-breeding will be commenced on a small scale at Dacca with Chittagong and Langshan fowls. An enquiry will be made as to the desirability or otherwise of introducing a new and superior polyvoltine race of silk-worm said to have been bred by Messrs. Anderson, Wright & Co. of Berhampur by crossing the Italian with the local "Nistri" worms. At Shillong, the experiment with the European univoltine silk-worms, which have proved successful for six years in succession, will be continued. If time permits, the Fibre Expert proposes to study the retting of jute and Sunn-hemp from the Chemical and Bacteriological point of view.

7.—Forest Department.

Programme of work to be carried out at the Imperial Forest Research Institute, Dehra Dun, during the three Forest years 1910-11 to 1912-13.

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute.*

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
1	The conversion of an irregular Sâl forest into a regular Sâl forest, experiment to be carried out on a practical scale, a careful working scheme being prepared for the Thano experimental area.	Sylviculturist and Superintendent of Working Plans.	Thano Experimental area, Debra Dun District, U. P.	It is recognized that owing to the prevalence of frost in the Thano forest, it will be necessary to extend the experiment to other localities, where more favourable climate conditions exist, in order to obtain conclusive results.

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
2	Experiments to ascertain the best methods of ensuring natural regeneration of Sâl; severity of cuttings to bring it about, and the degree to which young Sâl will stand shade.	Sylviculturist and Superintendent of Working Plans.	Thano Experimental area, Dehra Dun District.	.....
3	Methods of artificially cultivating Sâl and assisting natural reproduction to be tested, and experiments made.	,,	Thano Experimental Station, Dehra Dun, U. P.	The experiments under this head being carried out in Kheri Division, U. P., and elsewhere, will be visited and the results obtained there will be tested in Thano, as well as such other experiments as may suggest themselves. Other experimental stations may also eventually be started in Sâl localities where special difficulties are being encountered.
4	The effect of age of tree on fertility and abundance of seed; the frequency of seed years; the effect of environment on the same.	,,	,,	Notes will be collected from all Sâl forests visited, and reliable information obtained from other sources will be utilized.
5	Sâl coppice experiments and fertility of coppice seed.	,,	Gorakhpur Division, Gonda Division and other U. P. Sâl coppice areas.	.....

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
6	Investigation of effects of drought, fire, frost and grazing.	Sylviculturist and Superintendent of Working Plans.	For drought and fire: Kheri Division, United Provinces. For frost: Siwalik Division. For grazing:—Bahraich Division.	.....
7	Rate of growth of Sâl:—			
	(i) Rate of girth and height increment in high forests.	,,	(i) Siwalik Division	It will be impossible to obtain data applicable to the Sâl region as a whole and consequently it is considered that (i) at any rate should be left to local officers to investigate in areas in which the sylviculturist is unable to take the initiative. The investigation as regards (ii) should be undertaken by the sylviculturist.
	(ii) Yield tables for Sâl high forest and coppice.	,,	(ii) Gorakhpur Division.	
8	Thinnings in uniform Sâl crops; the age at which they should be commenced; their intensity, and the proper density to be maintained in crops of different ages.	,,	Wherever uniform crops are found in the United Provinces.	.....
9	Effect of subterranean water level and of geological formation (and soil drainage) on Sâl development.	,,	Kheri Division .	It is hoped that this investigation in the Central Provinces, especially as regards geological formation, will be undertaken by local officers.

Part I.—Investigations into certain matters connected with the Sâl *tree* (*Shorea robusta*) *by all members of the Research Institute*—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
10	Collection of notes and information regarding other matters relating to Sâl, including the companions associated with it in natural forests.	Sylviculturist and Superintendent of Working Plans.	Kheri Division .	.....
*11	The pollination of the flowers and distribution of the seeds of Sâl. Description and illustration of fruit, seed, process of germination and the seedling.	Botanist .	Most of these investigations will be carried out at the Research Institute, short tours being arranged as required.	*Note.*—The items marked with an asterisk will first be taken in hand.
*12	Study of the conditions favourable and unfavourable for successful germination and early development. This will include among other things the determination of the most suitable physical conditions of the soil.	,,	.....	For the purposes of these investigations analysis of soils selected by the Botanist will be carried out by the Chemist The method of analysis to be adopted in each case will be decided by the Botanist and Chemist in consultation.
*13	The dying back of seedlings and its causes. How does dying back interfere with the normal development of root and shoot, and does it induce decay in the mature stem?	,,	.....	.....

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
*14	Study of grasses characteristic of Sâl forest with special reference to— (*a*) Preparation of descriptions and illustrations, enabling the various species to be easily recognised. (*b*) Their relation to Sâl, their competitive action, excretion of poisonous substances, increasing damage by frost, etc. (*c*) Their value as indicators of soil suitable or unsuitable for Sâl. (*d*) Their economic value in preventing erosion, as fodder plants and in other ways. (*e*) Effect of fire and grazing upon them. (*f*) Best method of propagating or increasing the proportion of the more valuable species.	Botanist .	.....	This investigation is in progress.
15	Study of the diseases of Sâl whether caused by fungi or otherwise.	„	Wherever found in Sâl forests.	.....

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
16	Technical properties of wood— (*a*) To carry out experiments with regard to the shearing, crushing and bending strength of wood of seedling and coppice origin, respectively; seasoned and green— (i) Grown in the hills. (ii) Grown in the plains. (*b*) To test the fissibility of wood of seedling and coppice origin, grown in the hills and plains, seasoned and green— (i) Vertically and tangentially. (ii) Vertically and radially. (iii) Horizontally and tangentially. (iv) Horizontally and radially.	Economist .	Research Institute and Sibpur Engineering College.	It is proposed to send the wood to Sibpur for testing, provided the Sibpur authorities can undertake the work.

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
	(*c*) The time taken for Sâl to season under various conditions, and the best methods of seasoning, with special reference to the liability of the timber to crack, warp and shrink. (*d*) The specific gravity of timber of (i) seedling, (ii) coppice origin, grown at various altitudes and on different soils and aspects. (*e*) The relative properties of wood when felled at different times of the year.			
17	Durability— . .	Economist .	.....	
	Investigations regarding— (*a*) The life of Sâl timber when used (i) under cover; (ii) in the open; (iii) under water. (*b*) The life of Sâl sleepers. (*c*) The effects of iron fastenings on Sâl sleepers.			

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
	(*d*) The effect of various antiseptic solutions on Sâl timber.			
18	Uses to which the products of Sâl can be put—	Economist .	.....	
	(*a*) Major, *e.g.*, timber.			
	(*b*) Minor, *e.g.*, resin, oil, bark tanning extracts and fibre.			
19	The calorific value of wood when used as (i) fuel, (ii) charcoal.	"	.....	
20	Supply of market for Sâl—	"	.....	
	(*a*) Enquiry as to the actual annual outturn of Sâl timber—			
	(i) from Government forests.			
	(ii) from private forests so far as the principal markets are concerned.			
	(*b*) General note on past and present prices of Sâl timber.			

Part I.—Investigations into certain matters connected with the Sâl *tree (Shorea robusta) by all members of the Research Institute*—concluded.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
	(*c*) The available annual supply of Sâl sleepers and the past and present prices of the same. (*d*) Past and present prices of minor products, and possibility of improving the demand. (*e*) Forecast of the Sâl trade.			
21	The study of all insects which cause serious damage to, or which are beneficial to the Sâl tree or its timber.	Zoologist .	.....	*Note.*—With regard to Sâl *insect pests* a considerable series of investigations have already been undertaken, and the results have been published or are under publication. The Botanist and Sylviculturist will be able to render considerable assistance in this study.
22	A special enquiry into Sâl bark tanning extracts.	Chemist .	.....	

Note.—It is recognised that the general restriction during the next three years of investigations regarding the Sâl to the United Provinces may not be advantageous from the point of view of acquiring data applicable to this species throughout India, but, owing to the paucity of the staff sanctioned for the Sylvicultural branch of the Institute, it is considered that this cannot be avoided at present. As soon as the necessary staff is forthcoming investigations should be extended to Bengal, Eastern Bengal and Assam and the Central Provinces.

Part II.—Investigations into various subjects by the officers of the Imperial Forest Research Institute.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
1	The Uniform and Group methods of working forests. Enquiries will be made as to the suitability of these two methods, or modifications of them, in Indian forests.	Sylviculturist and Superintendent of Working Plans.	Forests under these methods of treatment, or which it is proposed to put under them, may be visited, *e.g.*, the Chir forests of the United Provinces, the Teak forests of Burma (Tharrawaddy and Mohnyin) and Sâl forests of the Kumaon Division, United Provinces.	
2	Compilation of statistics of plantations of various species and enquiries, if necessary, into any difficulties met with in the propagation of any particular species, including an enquiry as to the best density to be maintained at different periods. This is in progress for several species, but before anything reliable can be published visits to many of the plantations concerned will be found necessary.	„	The United Provinces.	

Part II.—Investigations into various subjects by the officers of the Imperial Forest Research Institute—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
3	Investigation into the best methods of cutting and working bamboos. Detailed experiments will be carried out in specially demarcated plots.	Sylviculturist and Superintendent of Working Plans.	Siwalik and Ganges Divisions, United Provinces.	
4	The cultivation of trees for the growth of lac experiments, which have been commenced, will be continued with reference to the best methods of (i) preparing trees for the reception of lac, and (2) working prepared trees in rotation.	,,	Siwalik Division, United Provinces.	This will be carried out in conjunction with the Economist.
5	Sylvicultural Notes on various species. The collection and collation of statistical and other data regarding the chief Indian trees and types of forest, commencing with deodar, *Pinus excelsa* and *Pinus longifolia*. The preparation of yield tables and the collection of data for fixing the exploitable size and age as well as the possibility in forests under the different sylvicultural systems.	,,	The United Provinces.	The progress of this enquiry must depend to a great extent on information communicated by local officers.

Part II.—Investigations into various subjects by the officers of the Imperial Forest Research Institute—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
6	Study of teak, including the factors favouring the rapid germination of the seed and the development of the young plant; the dying back of seedlings, the mode of origin of coppice shoots, the structure of young and old seedling and coppice plants and pollination of the flowers.	Botanist .	.....	A quantity of plants of various ages and of coppice shoots collected in various forests in the Central Provinces are now in hand. A preliminary pamphlet on teak coppice is in the Press and others will follow as the material collected is worked up. Germination experiments have also been commenced.
7	Detailed systematic study and description of all forms of forest plants of economic value, when such is required, owing to the commercial importance of the species and to the fact that the existing classification and description are unsatisfactory and confusing.	,, .	.....	
8	The study of the fungoid diseases affecting the blue pine in the Punjab and the Casuarina in Madras. Also of the spike disease of sandal in Madras.	,, .	.....	
9	An experimental botanical garden will be laid out and maintained in good order.	,, .	Dehra Dun, United Provinces.	

Part II.—Investigations into various subjects by the officers of the Imperial Forest Research Institute—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
10	Wood, bamboo and grass pulp— (*a*) Woods, bamboos and grasses suitable for the manufacture of pulp, and the available supply. (*b*) Suitable sites for factories. (*c*) The financial aspect of the business.	Economist .	India and Burma generally.	
11	To keep under observation and encourage the match business in India, which is already started but which is still not firmly established.	„ .	.....	
12	Antiseptic treatment of woods— To carry out experiments with various antiseptic processes, with special reference to the use of important inferior species for railway sleepers.	„ .	.....	
13	Investigations into the physical properties and seasoning powers of various woods.	„ .	.....	For details see items 16 and 17 in Part I.
14	Enquiry as to the use of and the possibility of putting certain gums, resins and oleo-resins on the European markets.	„ .	.....	In communication with the Reporter on Economic Products.

Part II.—Investigations into various subjects by the officers of the Imperial Forest Research Institute—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
15	Investigations to be carried out with regard to the disposal of products obtained from the destructive distillation of woods.	Economist .	.....	In conjunction with the Chemist.
16	Enquiry as to the commercial value of certain oil-seeds.	„ .	.....	In communication with the Reporter on Economic Products.
17	Investigations regarding woods suitable for— (i) Packing cases. (ii) Tea boxes. (iii) Opium chests. (iv) Paving blocks. (v) Railway rolling stock. (vi) Carriage building. (vii) Harbour construction. (viii) Other miscellaneous purposes, such as pencils, pipes, hair brushes, fishing rods, veneers, cooperage, etc.	„ .	.....	
18	Description of the woods at present little known in the market— Yearly a number of woods will be examined and information collected on each species likely to prove of commercial importance, with a view to bringing them to public notice.	„ .	.....	This work will be in continuation of a series of articles already published.

Part II.—Investigations into various subjects by the officers of the Imperial Forest Research Institute—continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigation will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
19	Resin tapping of conifers and enquiry into the possibility of improving the present system of distillation.	Economist .	.....	In conjunction with the Chemist.
20	Enquiry into the subject of useful fibres.	„ .	.....	
21	Enquiry as to the use, if any, of *Strobilanthes Spp., e.g.*, the flowers contain an oil.	„ .	.....	
22	Enquiry as to the suitability of various tan barks, especially *Terminalias* and Oaks.	„ .	.....	In conjunction with the Chemist.
23	Enquiry into the best method of disposing of resin, including the preparation of a list of the industries in which it is used, with the names of the firms engaged in these industries.	„ .	.....	
24	Enquiry into the most profitable method of disposing of lac.	„ .	.....	In conjunction with the Chemist.
25	Preparation of a satisfactory reference collection of insects for the Research Institute.	Zoologist .	.....	This collection should be confined to insects of practical importance from a Forest point of view.
26	Investigation regarding the lac insect.	„ .	.....	This investigation will be carried out in conjunction with the Agricultural Research Institute at Pusa.

Part II.—Investigations into various subjects by the officers of the Imperial Forest Research Institute--continued.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
27	Rusa grass oil, to study the causes of differences between the two varieties, Motia and Sophia, and the possibility of the conversion of Sophia-oil into Motia-oil.	Chemist .	.. ...	In communication with the Reporter on Economic Products. *Note.*—These investigations will be carried out chiefly in the laboratory of the Imperial Forest Research Institute.
28	The commercial possibilities of the manufacture of shellac by various processes. (In hand).	,, .	.....	In conjunction with the Economist.
29	Distillation of *Blumea balsamifera* on a commercial scale (in hand); and of *Cinnamomum glanduliferum*.	,, .	.....	
30	Oil-yielding forest seeds, their oil value and the determination of the constituents of various oils.	,, .	.. ...	In conjunction with the Economist, and in communication with the Reporter on Economic Products.
31	Destructive distillation of Indian woods including the manufacture of Ethyl Alcohol.	,, .	.. ...	
32	Manufacture of decolourised Mangrove extract on a commercial scale.	,, .	.. ...	
33	Decolourisation and clarification of Indian Colophony. (In hand.)	,, .	.....	

Part II.—Investigations into various subjects by the officers of the Imperial Forest Research Institute—concluded.

Serial No.	Subjects and details of investigations.	Officer by whom investigations will be carried out.	Localities in which investigations will first be taken in hand.	Remarks.
34	Distillation of miscellaneous fragrant grasses, *e.g.*, khas oil, and the investigation into the properties of the essential oils obtained from them.	Chemist .	.....	
35	Examination of the resins of the principal conifers in connection with the production of turpentine.	„ .	.....	
36	Investigation regarding the best season for the collection of myrabolams so as to obtain the greatest yield of tannin.	„ .	.....	
37	Enquiry regarding collection and utilization of the milk of *Dichopsis elliptica*.	„ .	.....	

8.—Natural History Section, Indian Museum.

The programme for the Natural History Section of the Indian Museum must again be a provisional one, as two of the three new Assistant Superintendents have not yet reached Calcutta. The work noticed in last year's programme will, however, be continued, special attention being paid to blood-sucking Diptera of the families *Muscidæ* and *Psychodidæ* and to fresh-water fish.

9.—Civil Veterinary Department.

By the Imperial Bacteriologist :—

(1) *Anthrax.*—To continue the investigations laid down in the programme of the previous year.

(2) *Surra.*—To continue experiments in methods of treatment and prophylaxis.

(3) *Rinderpest.*—Investigations as to possibility of preparing serum for buffaloes; and also the use of other than hill bulls for the preparation of serum for bovines.

(4) Further tests of serums and vaccines prepared during the past two years.

By the Officer investigating Camel diseases :—

(1) Investigations into Surra in the field.

(2) The study of Filariasis in the camel.

(3) Treatment of Surra in the camel.

By the Provincial Staff.—Punjab Veterinary College Laboratory :—

(1) Treatment of Surra.

(2) Study of Hæmorrhagic Septicæmia.

By Provincial Superintendents :—

Collection of information and the mapping out, as opportunity occurs, of the incidence of Surra, Piroplasmosis, Hæmorrhagic Septicæmia and Anthrax.

APPENDIX.

APPENDIX.

REPORT ON SCIENTIFIC AND TECHNICAL INVESTIGATIONS CONDUCTED FOR INDIA AT THE IMPERIAL INSTITUTE DURING THE YEAR ENDED 30TH SEPTEMBER 1910.

The scientific and technical investigations which have been in progress at the Imperial Institute for the Government of India during the year ended the 30th September 1910, are as follows :—

(1) **Opium.**—The examination of the constituents of a large number of specimens of opium collected at the instance of the Government of India in the various districts of India has been in progress. Over 100 samples in all have been submitted for complete investigation and the work is now approaching completion.

(2) **Solanaceous** plants.—In connection with the examination of Indian Solanaceous plants, a report on the leaves and seeds of *Datura Metel* was completed during the year. Further specimens of *Datura Metel* and of *Hyoscyamus niger* were also under examination.

(3) **Aconites.**—The investigation of Indian aconites has been in abeyance owing to the requirements of the Indian opium enquiry. It is hoped to be able to resume this investigation, which promises interesting results, during next year.

(4) **Tobacco.**—Samples of tobacco grown experimentally at the Government Burirhat Farm at Rangpur, Eastern Bengal and Assam, and at the Nadiad Agricultural Station in the Bombay Presidency, have been examined and reported on. The nature and composition of the tobacco was ascertained and expert opinions obtained regarding its quality and value. Recommendations were made in the reports for the improvement of the tobaccos.

(5) **Lac.**—Specimens of lac prepared by a special process by the Imperial Forest Chemist were examined and submitted to technical trials. It appeared that the lac was rather darker than the best shellac and that there would be considerable prejudice against the form in which it was prepared. Larger samples for further technical trials were, however, requested.

An examination of lac from the "rain tree" (*Pithecolobium Saman*), forwarded from Baroda, showed that the material was of fair average quality.

(6) **Monazite sand.**—Samples of monazite sand from Travancore have been examined and reported on. The opportunity was taken of referring to analyses of other specimens of the same sand previously received at the Imperial Institute.

In addition to the above-mentioned investigations a large number of products received from the Officiating Reporter on Economic Products and other Indian officials have been examined and reported on during the year. These have included cotton, jute and other fibres, cotton-seed oil and ghi, lemon grass oil, foodstuffs and minerals.

The facilities offered by the Imperial Institute for obtaining independent and trustworthy information respecting the intrinsic and market values of Indian commercial products are being more generally recognised, and a great deal of such information has been supplied to numerous Government officials in India, and to merchants and firms in India as well as in the United Kingdom.

In this connection it may be mentioned that several reports have been drawn up at the request of the Government of Mysore on the subject of the production and the commercial prospects of sandalwood, with special reference to the present and future market for the Mysore wood.

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Departmental Publications.

I.—Department of Economic Products.

(1) The Agricultural Ledger—a series of papers on Economic Products issued as ready and priced according to the number of pages.
(2) Commercial Circulars printed for circulation but not on sale.
(3) Annual Report of the Industrial Section, Indian Museum.

II.—Meteorological Department.

Government of India Office.

(1) The India Daily Weather Report and Chart.
(2) The Weekly Rainfall Summary.
(3) The Monthly Weather Review.
(4) The Annual Summary.
(5) The Rainfall of India.
(6) Indian Meteorological Memoirs.

Bengal Office.

(1) Bengal Daily Weather Report and Chart.
(2) Monthly Rainfall tables and Summaries of the chief features of the weather of the month over Bengal.

Bombay Office.

(1) Bombay Daily Weather Report and Chart.
(2) Monthly Abstracts of the Bombay observations (*Bombay Gazette*).

Madras Office.

(1) Bombay Daily Weather Report and Chart.
(2) Monthly Rainfall tables (*Madras Gazette*).

Allahabad Office.

(1) Monthly Weather Summaries (*United Provinces Gazette*).
(2) Annual Summary.
(3) Monthly Rainfall tables (*United Provinces Gazette*).

Lahore (Simla) Office.

(1) Monthly Summary
(2) Annual Summary } of Punjab weather.

III.—Geological Survey.

The publications of the Department include—

Palæontologia Indica arranged in series, and sold in parts which are priced at 4 annas (6 pence) per plate.

Memoirs, Vols. I—XXXVIII, including the larger papers on geological subjects.

Records, Vol. I—XL, including the shorter papers and Annual Reports from 1868 to 1910 sold in parts, price one rupee each.

Manuals, Guides and Maps.

A complete list of the contents of these publications can be obtained by application to the Registrar, Geological Survey of India, 27, Chowringhi Road, Calcutta. Indexes to the Genera and Species described in the Palæontologia Indica up to 1891; to the Memoirs, Vols. I—XX, and to the Records, Vols. I—XXX, have been printed for sale.

IV.—Survey of India.

(1) Annual General Report.
(2) Professional Papers.

V.—Botanical Survey and Royal Botanic Garden, Calcutta.

(1) Annual Report of the Botanical Survey of India.
(2) Records of the Botanical Survey, Vols. I—III, Vol. IV, Nos. 1—4 and Vol. V, No. 1.
(3) Annual Report of the Royal Botanic Garden, Calcutta.
(4) Annals of the Royal Botanic Garden, Calcutta, Vols. I—XII.

A list of the contents of the Records and of the Annals with prices of the numbers and volumes still available can be obtained by applying to the Superintendent, Royal Botanic Garden, Calcutta.

VI.—Department of Agriculture.

(1) *Annual Report.*—An account of the year's work of the Imperial Department, including the separate reports of the scientific officers of each branch (Agricultural Chemistry, Botany, Mycology, Entomology, and the like).

(2) *The Agricultural Journal of India.*—A quarterly journal containing articles on agricultural matters intended for the educated agriculturist and the general reader interested in Agriculture.

(3) *Scientific Memoirs of the Department of Agriculture.*—An occasional publication for papers of a scientific or technical nature divided into series such as Chemical, Botanical, Entomological, and the like.

(4) *Bulletins.*—An occasional publication containing information on agricultural matters of a temporary nature.

(5) *Leaflets.*—Short notes of practical instruction in agricultural matters, dealing mainly with entomological subjects.

VII.—Forest Department.

(1) *Review of Forest Administration in British India* by the Inspector-General of Forests (issued annually).

(2) *Annual Progress Report of Forest Administration in each Province.* —Issued by the Local Governments annually.

(3) Indian Forest Records.

(4) Indian Forest Memoirs.

(5) *The Indian Forester.*—A monthly Journal of Forestry, Agriculture, Shikar and Travel. This is a Departmental Journal, published monthly.

(6) Bulletins are published from time to time.

VIII.—Zoological Department.

(1) The Annual Report—8vo.

(2) The Records of the Indian Museum, 8vo. Containing short papers on Indian zoology. One or two volumes issued annually in quarterly parts.

(3) The Memoirs of the Indian Museum, 4to. Containing monographs and other important papers. Published at irregular intervals.

(4) Descriptive Catalogue of Indian Decapod Crustacea, 4to. Parts published at irregular intervals.

(5) Descriptive Catalogue of Indian Echinodermata, 4to. Parts published at irregular intervals.

IX.—Civil Veterinary Department.

(1) Annual Report.

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